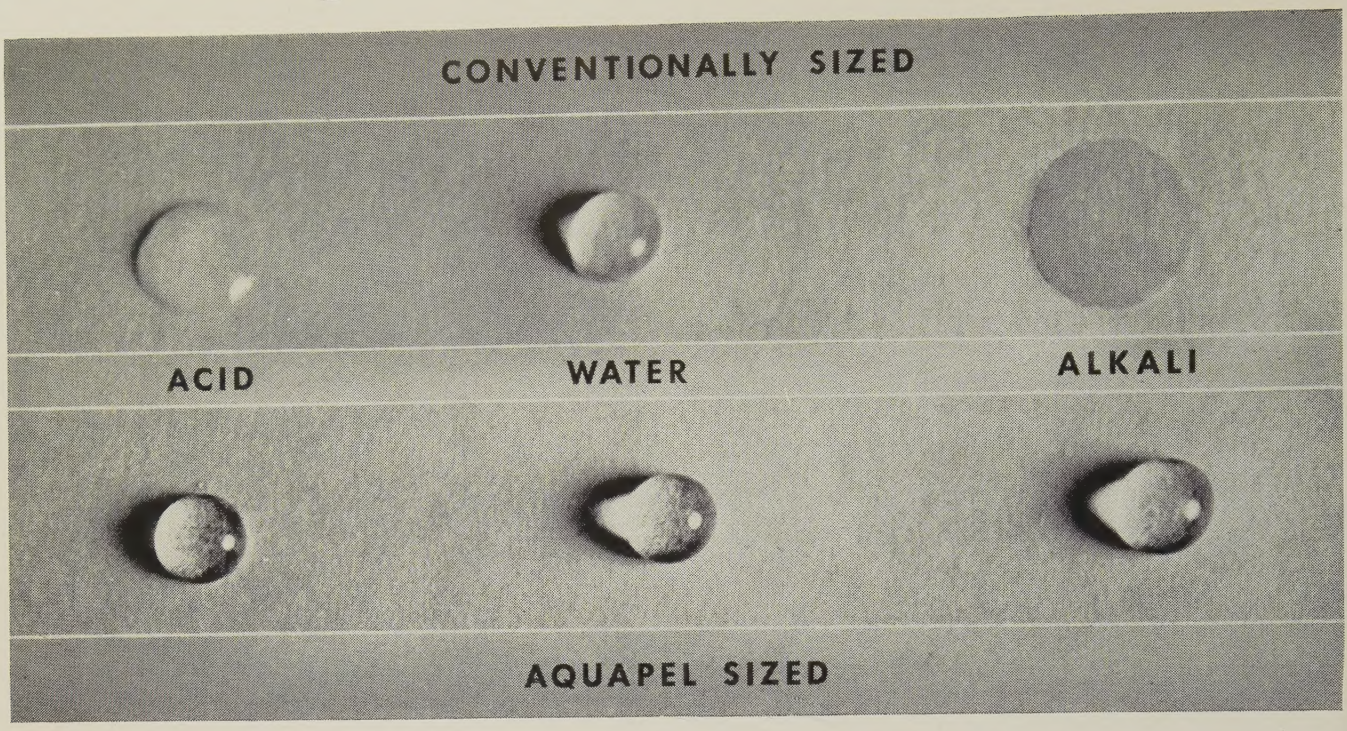
# Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JULY 1955

VOLUME 38 • NUMBER 7

# *These Drops Tell the Story:*




# ACID, WATER, OR ALKALI— IT'S ALL THE SAME TO AQUAPEL®

More and more paper mills are finding out that a little Hercules Aquapel can make a big difference. The photographs above tell part of the story.

The same grade of paper was used for both tests, but one sheet was conventionally sized; the other was Aquapel sized. Drops of acid, water and alkali were placed on both, and while the conventional sizing has resisted only the water, Aquapel has prevented all three from penetrating the surface.

One of the reasons for Aquapel's superior performance is that Aquapel is not just "another sizing agent". Aquapel is an entirely new concept in sizing for the paper industry. Neither resin nor wax, Aquapel is a chemical compound —an alkylketene dimer. It reacts chemically with cellulose fibers to form a surface that is resistant to penetration of cold water, hot water, acid and alkali. Aquapel sizing is not just "stuck on"; it becomes an integral part of the fiber.

There are other differences. For example, while Aquapel usually is applied on the surface, it is not a surface size in the usual sense. It replaces rather than supplements beater sizing with rosin size and alum.

Aquapel may be applied by any equipment commonly used for surface treatment of paper, such as the size tub, size press, calender box, spray or coating machine. And Aquapel is economical—a little goes a long way.

Investigate the Aquapel difference for yourself. Write Hercules for a sample, and descriptive literature.

*Paper Makers Chemical Department*

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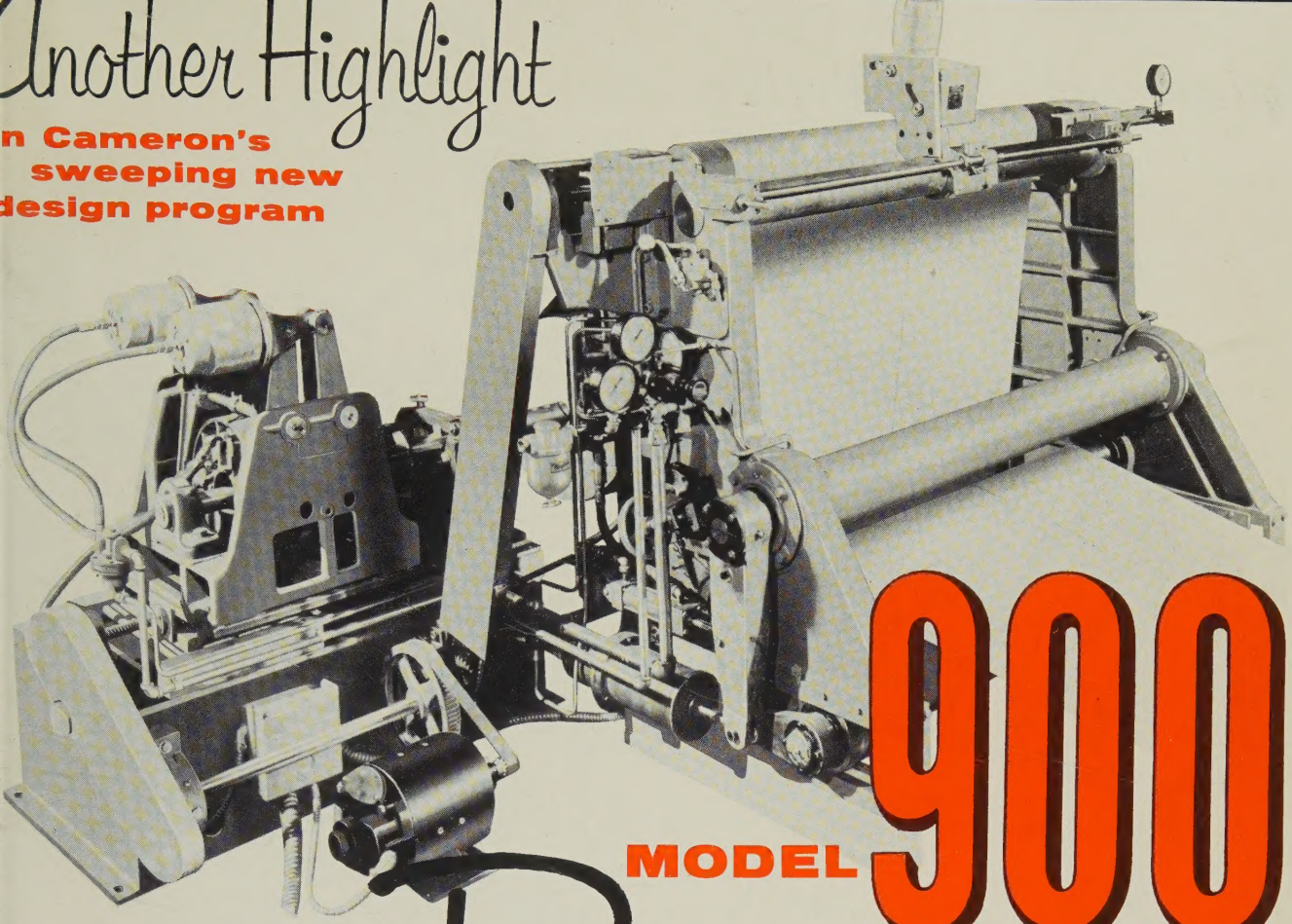
PP55-4

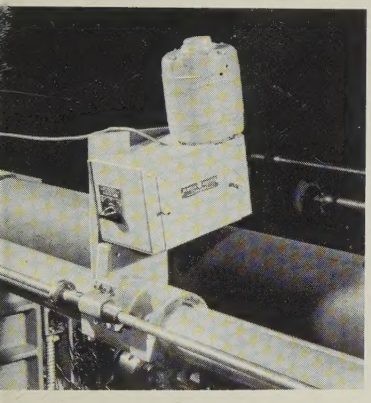
# Another Highlight

**n Cameron's sweeping new design program**



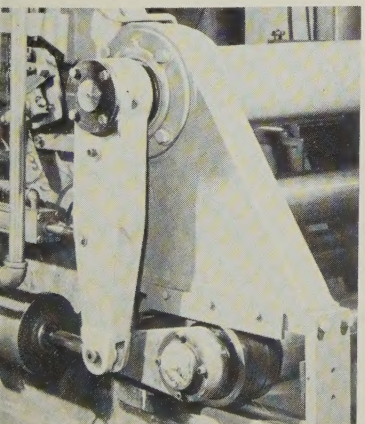
## MODEL 900

# Pneumatic Tension



**OVE:** The automatic photo-electric e register control features an anti-cklash, friction free traversing of nner roll for optimum accuracy and eed of response.

**LOW:** The cam-controlled pneumatic essure tensioning system provides treme sensitivity in tension control.



**THE NEW MODEL 900** pneumatic tension with automatic photo-electric side register control makes it easy to produce better finished rolls of all types of plain or printed materials. In one unit it provides automatic unwind tension control and electronic edge guiding, printed line guiding and printed pattern guiding.

**SENSITIVE CONTROL.** Extraordinary range and sensitivity of the new 900 permits handling a wide variety of materials, including stretchy plastic films such as polyethylene, vinyl and cellulose acetate; various grades of lightweight paper; and board. The low inertia, low friction tension roll provides automatic slack take-up and cushioning to reduce snap-offs and to maintain constant web control despite parent roll irregularities. The cam-controlled pneumatic pressure tensioning system is infinitely variable from zero to maximum. It is arranged for full stroke dancer roll travel regardless of tension setting. Versatility is apparent in the range of total controlled web tension . . . 200 to 1, or from 5 pounds distributed across the entire web to 1000 pounds.

**ACCURATE REGISTER.** The newly developed side register control operates instantly and accurately, whether guiding to a printed line or to the edge of the web. Its rate of response and correction is unmatched. On the standard unit the rate of correction is 60″ per minute with an accuracy of plus or minus 1/64″. The 900, with this control, is being used for high speed production of saleable rolls without trimming, and for hair line guiding on printed materials. A special unit of equal accuracy can be furnished with a correction rate of 120″ per minute.

**FLEXIBLE.** The double-disc, air-operated, water-cooled J-brake on the new 900 meets requirements for running light materials and yet is rugged enough for prolonged runs on heavier materials.

**THE 900** is built to handle web widths from 42″ to 92″ and parent rolls of either 42″ or 60″ diameter. Built with sturdy one-piece side frames. Anti-friction bearings used throughout. The tension control alone, without the side register control mechanism, is also available.

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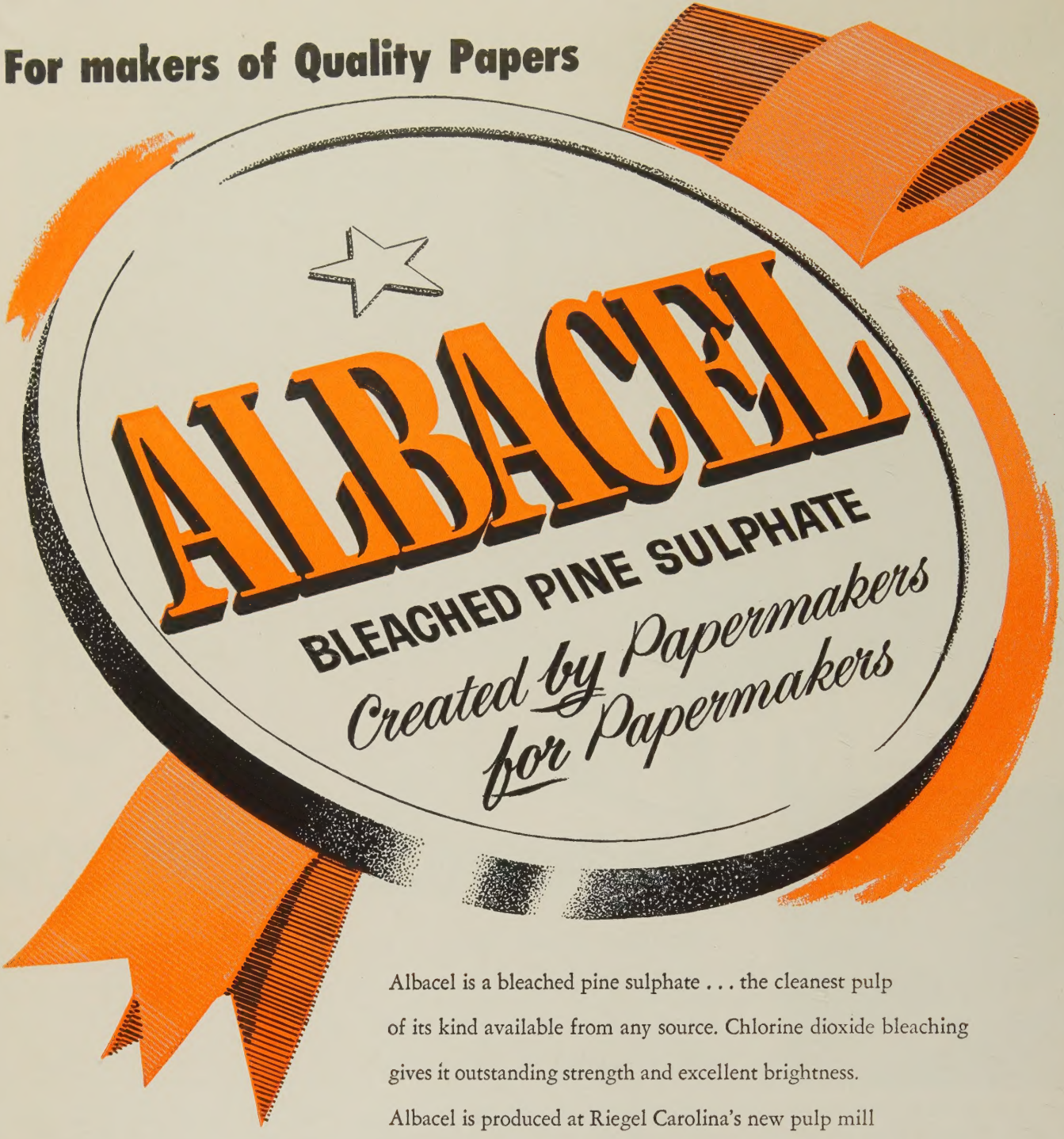


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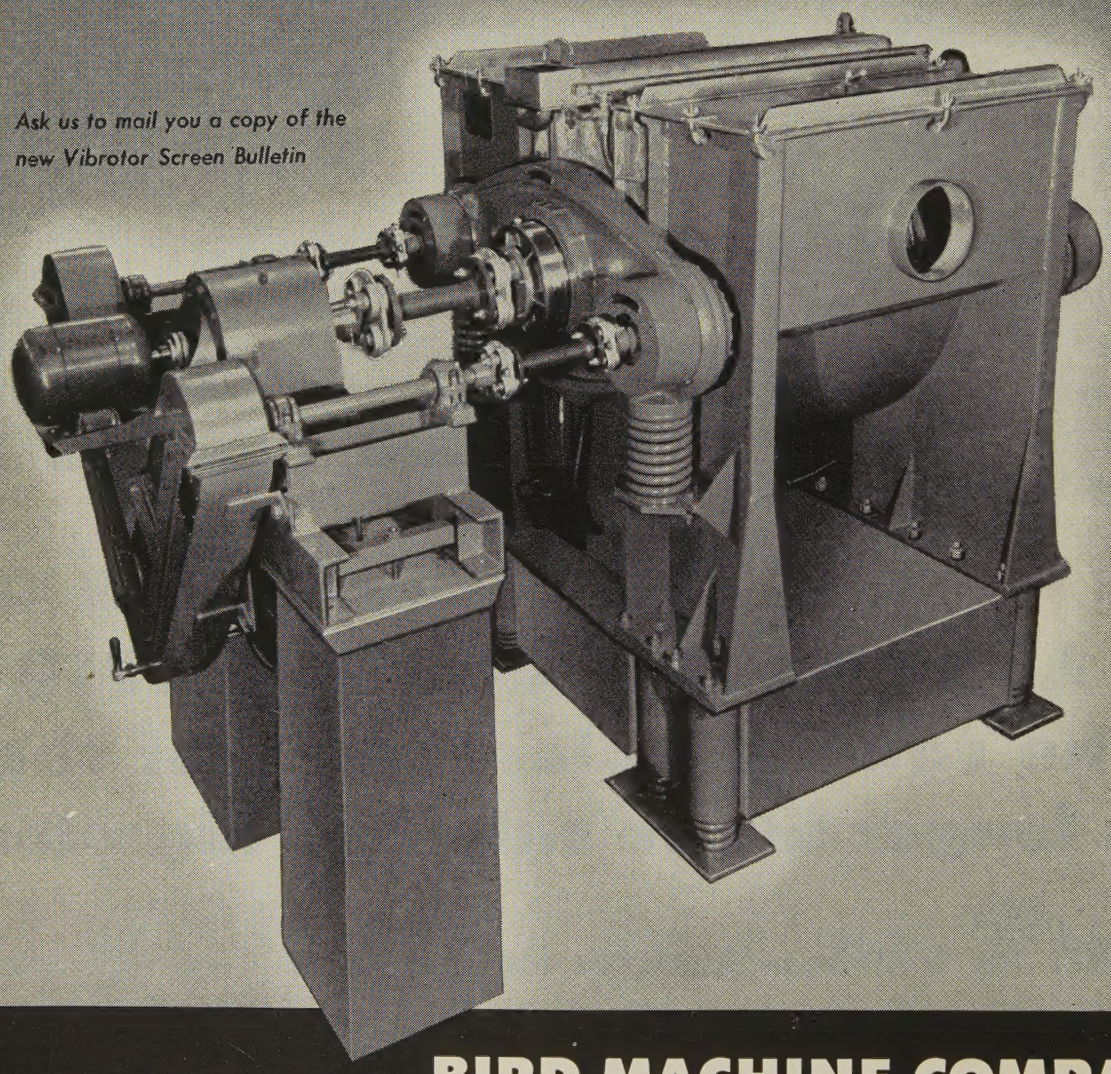

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JULY 1955

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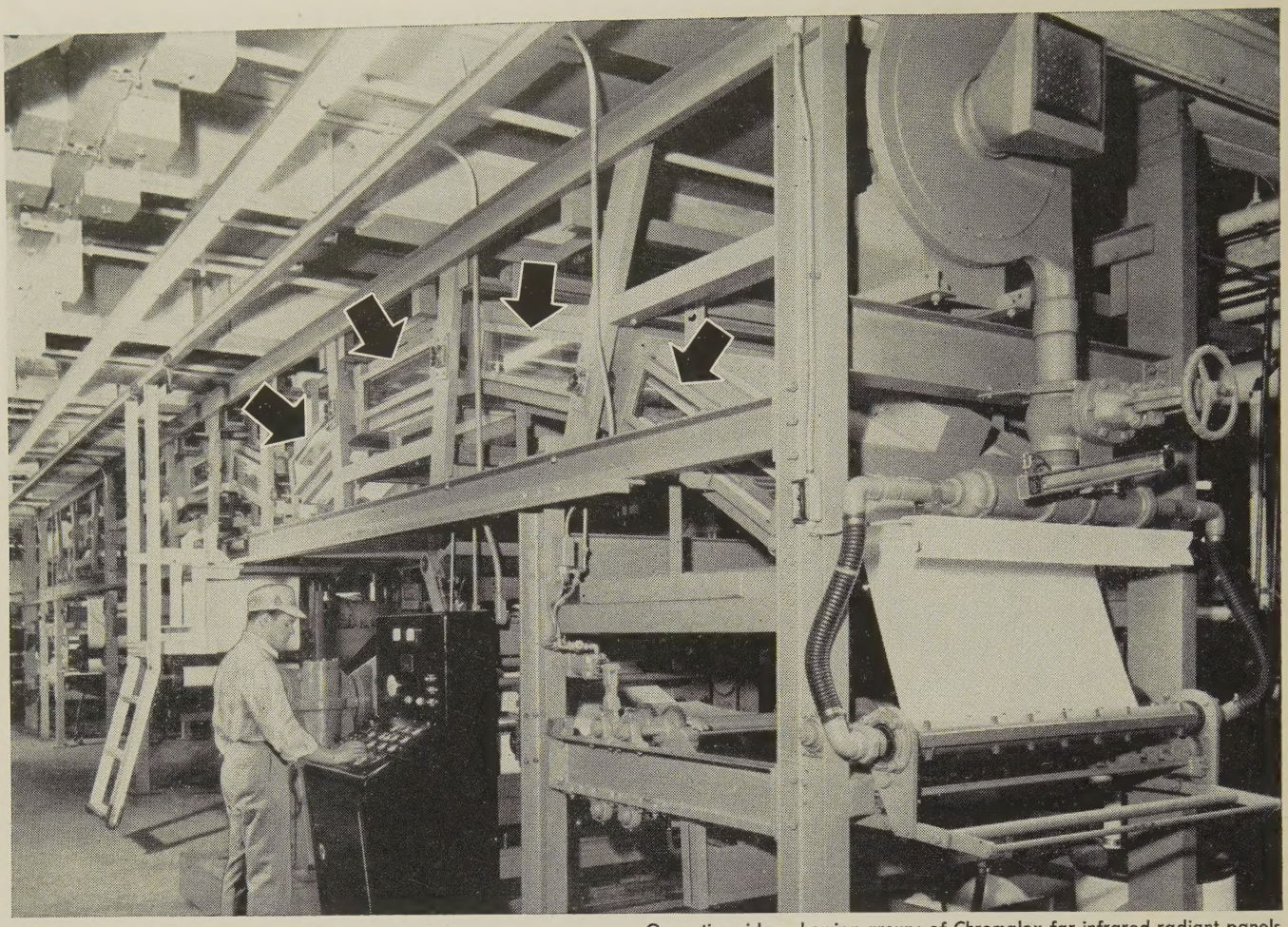

Operating side—showing groups of Chromalox far-infrared radiant panels

## electric radiant heating proves efficient in drying diazo coating on technical paper

To produce a diazo coated technical paper of consistent quality and uniform printing ability . . . without curl in cut sheets . . . this manufacturer found that essential factors are multiple station coating, precise heat control and no variables throughout the operation.

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Installed in a very limited space . . . 90′ long by 9′ wide by 12′ high . . . this infrared dryer handles paper up to 42″ wide. Present capacity is 54,000 square feet per hour. It is expected that, with added experience, the capacity can be materially increased.

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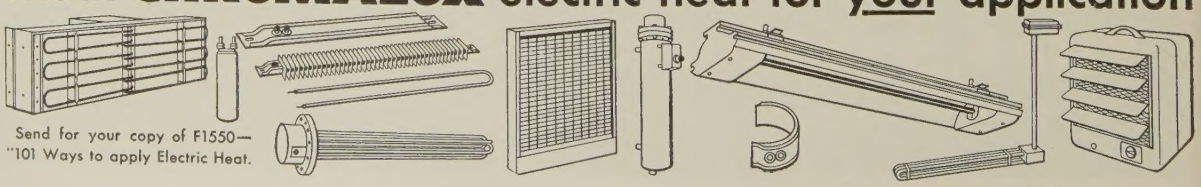

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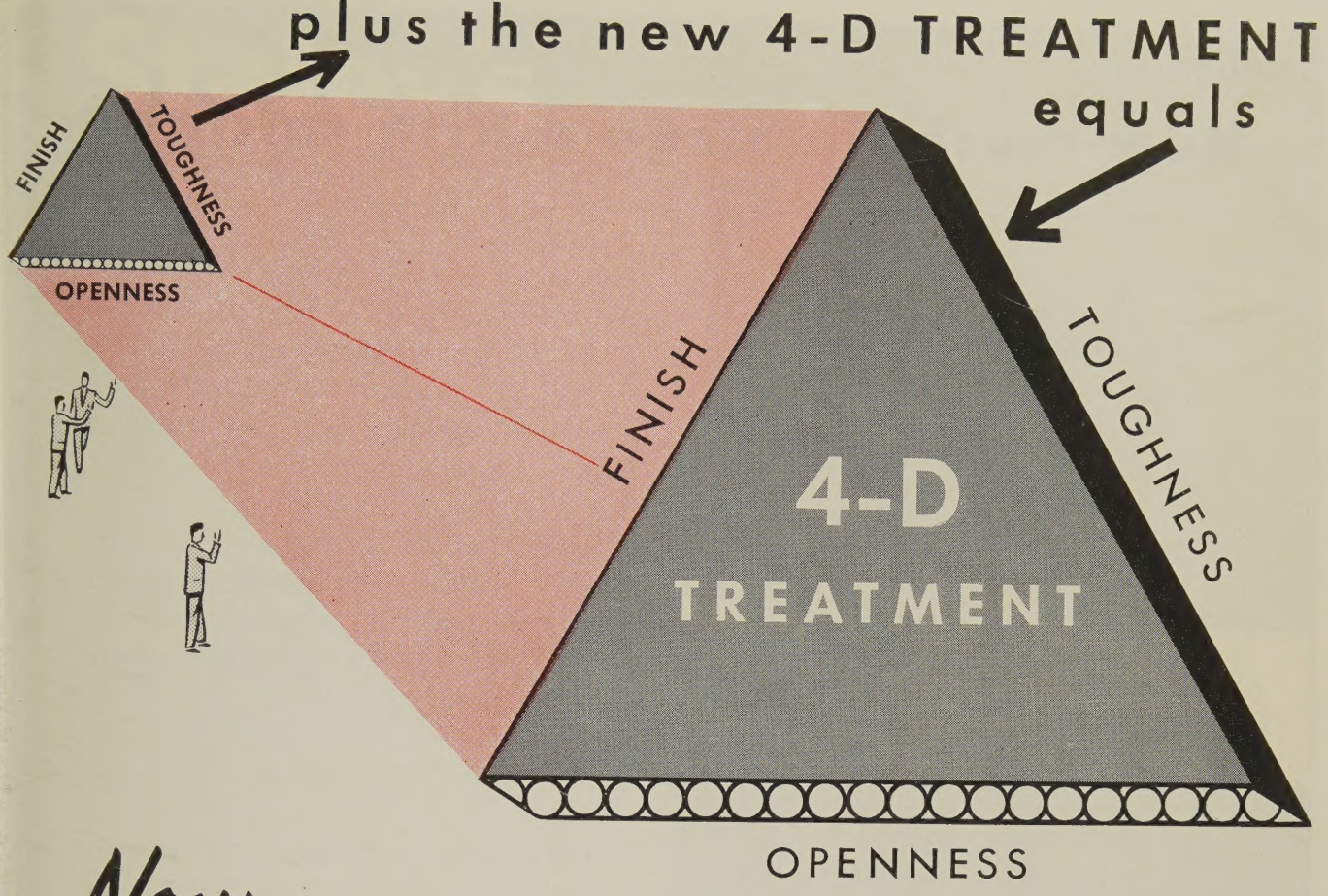


*Now—*

# HUYCK ADDS A 4TH DIMENSION TO FELT PERFORMANCE . . .

The two triangles * you see above illustrate the 3 essential properties of a papermaker's felt — *toughness* . . . *finish* . . . and *openness.*

The small triangle represents the limits of felt design *WITHOUT 4-D.* The big triangle shows how *4-D extends the limits of all design "legs" of the triangle.*

- 4-D increases toughness without sacrificing either openness or finish.
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In fact, 4-D improves TOUGHNESS and FINISH and OPENNESS *all at once.*

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Discuss the new 4-D TREATMENT with your "Man-from-Huyck." It will help you solve *your* felt problems!

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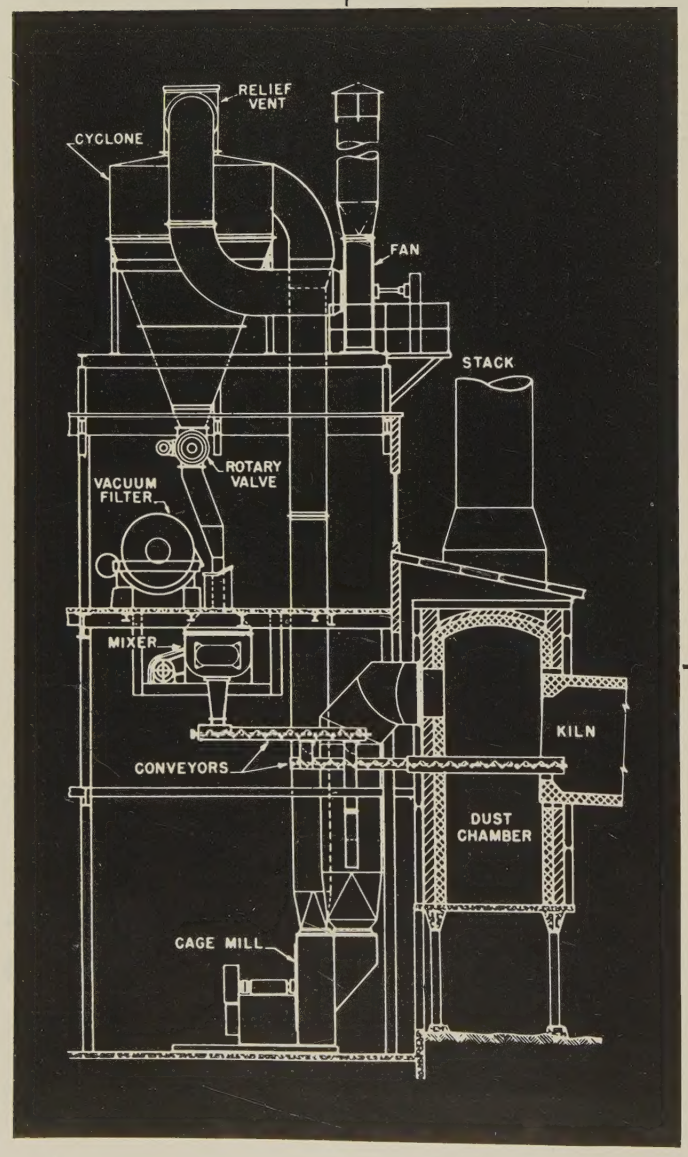


And the C-E Flash Drying System cuts costs all down the line. First of all, recovery is more complete — you use far less make-up lime. And because the C-E System uses waste heat from the kiln, over-all fuel costs are reduced. In fact, C-E Flash Drying Systems now in service are cutting total fuel consumption to nine to ten million Btu per ton of lime.

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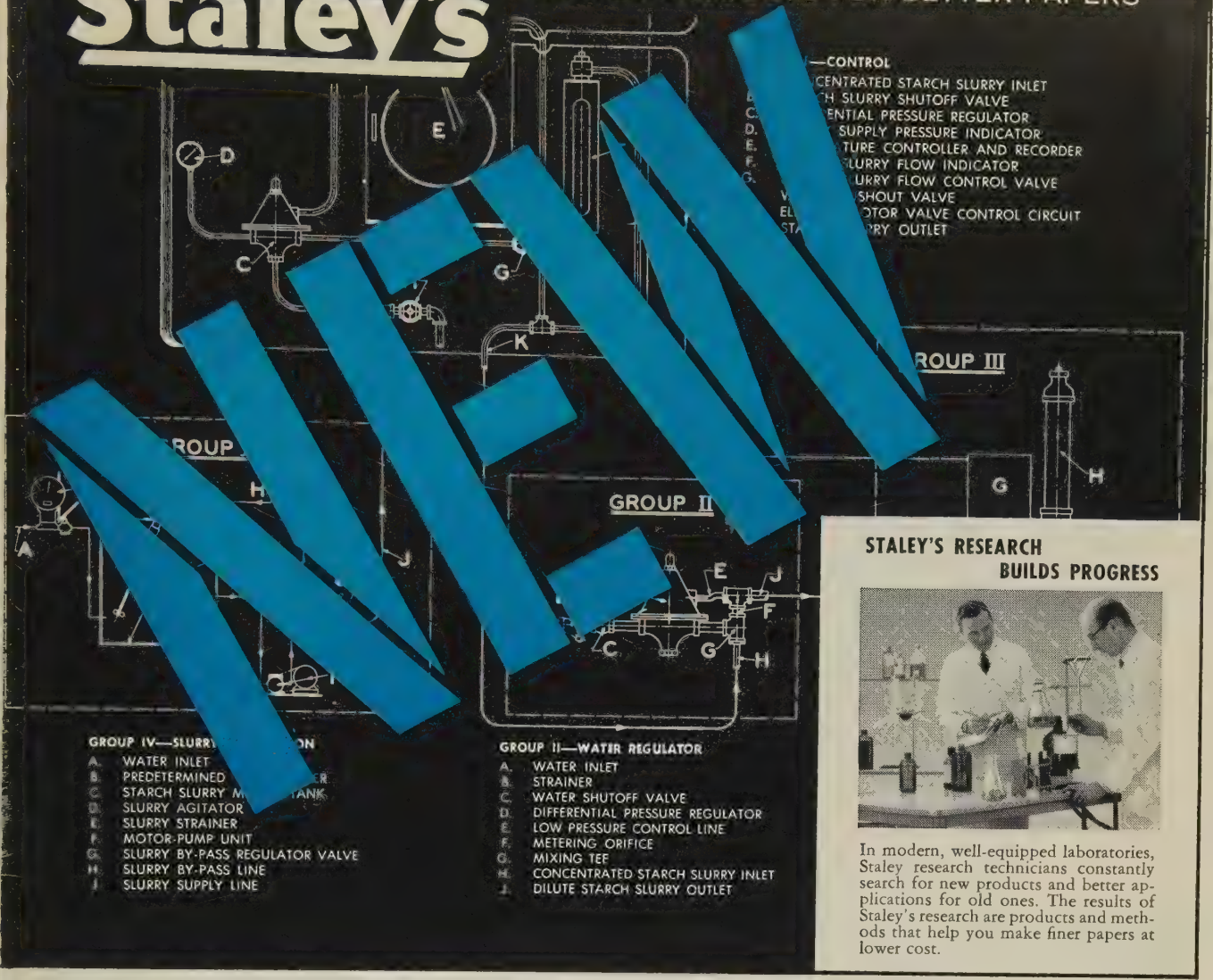


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NOW! After years of development and successful field testing, another major technological advance from Staley's . . . The Staley Jet System. This revolutionary apparatus provides for the first time *positive control over the full range of cooked starch properties and characteristics*, along with *continuous automatic addition* at the wet end.

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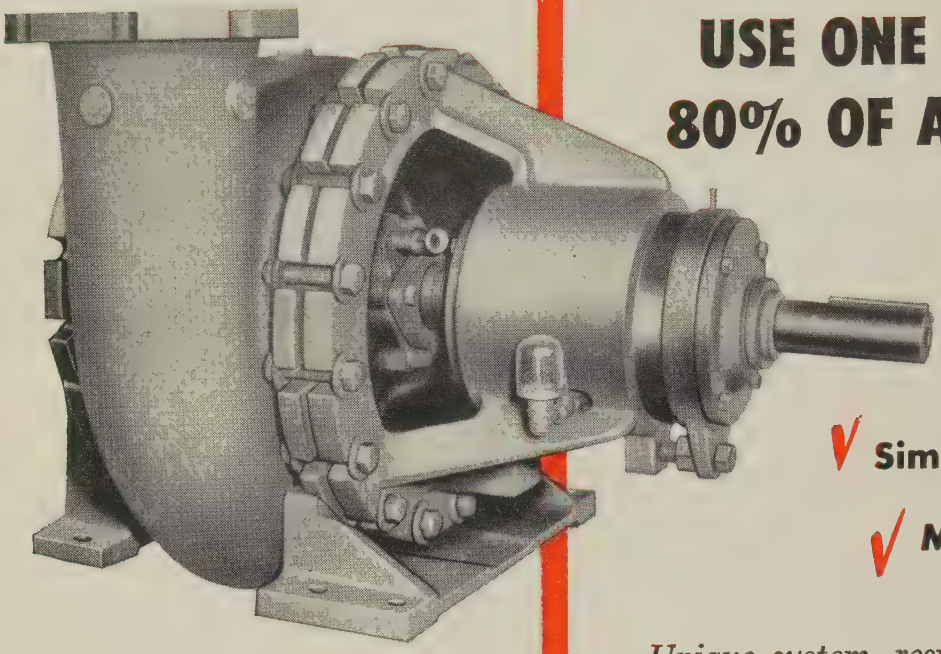
# Bowaters standardizes



## USE ONE DESIGN FOR 80% OF APPLICATIONS TO GET...

- ✓ Reduced spare parts stocks
- ✓ Simplified maintenance
- ✓ Maximum versatility

*Unique system, result of cooperative effort ...may set new industry trend.*

Working in close cooperation with Allis-Chalmers pump specialists, the designers of the new Bowaters Southern Paper Corp. mill standardized pumps far beyond the usual practice in paper mills. More than 120 of the pumps in the mill were built by Allis-Chalmers. Over 80% of these pumps are of one design, the Type PW, which has proved itself in use in paper mills throughout the world for many years.

By a careful study of pump requirements, it was possible to adapt this one design to a wide variety of requirements, including stock, white water, clear water, and liquor. The *Texrope* V-belt drives which power these pumps also were carefully selected to utilize only four sizes of belts while providing for the complete range of current and future drive needs.

As a result, Bowaters can carry fewer spare parts in stock... maintenance men save time and find work easier because there are fewer types of equipment to work on... head and capacity of each pump can easily be varied by a simple change in the *Texrope* drive.

*Texrope* and *Streambarker* are Allis-Chalmers trademarks.

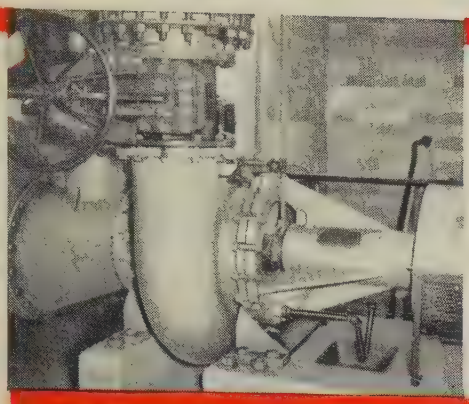
## Here's the Pump that does the job

Allis-Chalmers Type PW Paper Stock Pumps are especially designed for difficult stock and liquor pumping operations. Impeller design is non-clogging. Bearings are oil lubricated. Rotating parts may be removed for inspection or replacement and the pump returned to service in half an hour. Wearing clearance is adjustable with a single adjusting screw without dismantling any part of the pump. Capacities to 10,000 gpm with heads to 140 feet. Suitable for *Texrope* V-belt drive or direct connection. With four optional arrangements and accessories, the Type PW pump will handle up to 8% bone-dry consistence.

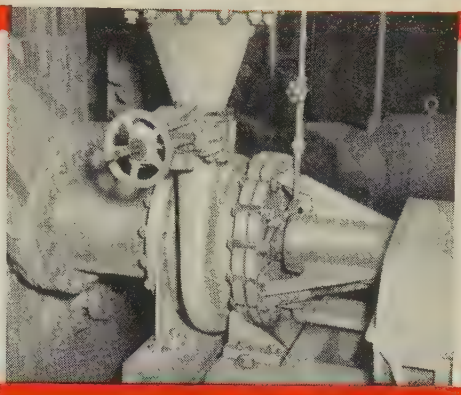
*For help on your paper mill equipment problems, call your nearby Allis-Chalmers District Office or write Allis-Chalmers, Milwaukee 1, Wisconsin.*

**ALLIS-**

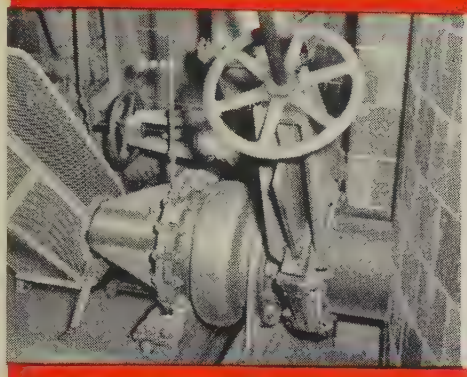
# with Allis-Chalmers Pumps



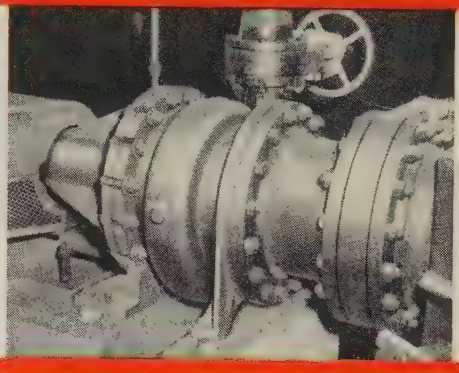
Type PWD 16 by 14 all-bronze pump handling 0.7% stock from bull screens.



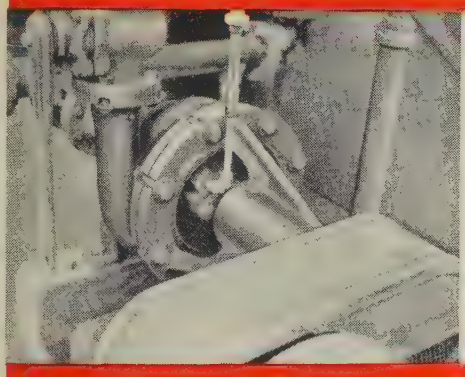
Type PWG 16 by 4 cast iron bronze-fitted pump handling 4.4% stock (heaviest in the mill) to pulp dryer.



Type PWG 16 by 6 cast iron bronze-fitted pump handling 4.0% screened stock to pulp dryer machine chest.

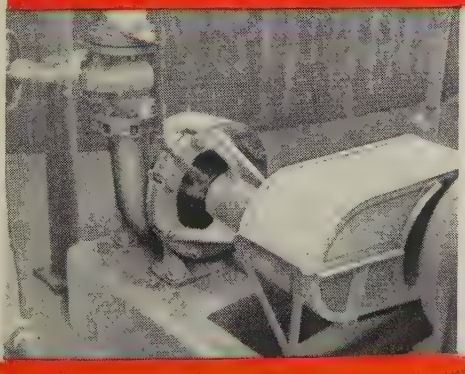


Type PWGOR 16 by 6 nickel cast iron blow tank stock pump handling 3.5% stock. This pump equipped with open impeller.



Type PWI 4 by 3 316 stainless-steel pump handling 1.1 specific gravity milk of lime.

Type LSC 30 by 24 bronze fan pump handling 0.6% stock to inlet box. This is one of the few stock, water or liquor pumps in the mill not of the Type PW design.



Type PWH 5 by 4 *Ni-Resist* pump handling 1.3 specific gravity concentrated black liquor to precipitating tank.

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# WORLD PULP AND PAPER RESOURCES AND PROSPECTS—II*

## WORLD PULP AND PAPER PRODUCTION 1913 TO 1950–52

BETWEEN 1913 and 1950–52 the world's production of paper and board has nearly quadrupled. Throughout this period Europe and North America together have accounted for nine tenths or more of the world total; but whereas Europe's share in world production before the First World War was about half, today it is little more than a quarter. North America's share, however, has risen to 64%.

### *Far East*

With an estimated 1951 population of 1205 millions, the Far East region includes roughly half the world's peoples; it consumes less than 2 million tons of paper and board annually, or about 4% of the world total. Roughly three quarters of its consumption are produced within the region, the other quarter being imported either from Europe or from North America. Consumption per head averages just over 1.5 kg., and, save for the Near and Middle East, is the lowest in the world.

Even this low figure, however, flatters, since, as Table XXXI shows, 59% of the total is consumed in Japan:

**Table XXXI. Paper and Board Consumption in the Far East, 1950–52**

Million metric tons

| | *Newsprint* | *Other paper and board* | *Total* | *Percentage of total* |
|---|---|---|---|---|
| Far East | 0.45 | 1.47 | 1.92 | 100 |
| Of which: | | | | |
| Japan | 0.19 | 0.94 | 1.13 | 59 |
| India | 0.06 | 0.20 | 0.26 | 14 |
| China (est.) | 0.09 | 0.12 | 0.21 | 11 |
| Others | 0.10 | 0.22 | 0.32 | 16 |

If Japan is excluded, consumption per head falls to the extremely low figure of 700 grams per head. It is probable that this figure slightly understates actual consumption, since the official data and estimates upon which they are based in all likelihood exclude the output of some cottage industries. It is not believed, however, that complete information, were it available, would significantly affect this estimate.

Both production and consumption have risen rapidly in recent years, while net imports have remained fairly steady (Table XXXII).

Thus total consumption of paper and board rose from 1,580,000 tons in 1950 to 2,220,000 tons in 1952. This increase was made possible by a 50% increase in the region's own production in the space of 2 years, imports from other regions rising by only 50,000 tons. Most, but by no means all, of this increase in output took place in Japan (Table XXXIII).

**Table XXXII. Production and Apparent Consumption of Paper and Board in the Far East, 1950–52**

Million metric tons

| | *Production* | | *Net imports* | | *Apparent consumption* | |
|---|---|---|---|---|---|---|
| | *Newsprint* | *Other paper and board* | *Newsprint* | *Other paper and board* | *Newsprint* | *Other paper and board* |
| 1950 | 0.21 | 0.96 | 0.16 | 0.25 | 0.37 | 1.21 |
| 1951 | 0.25 | 1.32 | 0.17 | 0.22 | 0.42 | 1.54 |
| 1952 | 0.36 | 1.40 | 0.20 | 0.26 | 0.56 | 1.66 |

From 1950 to 1952, the rise in Japanese production was more rapid than that in the rest of the region, but even outside Japan production rose by about 40%. The further increase which has taken place in Japan in 1953 is somewhat surprising. The truce in Korea has not yet led to any slowing down of the rate at which production is expanding.

**Table XXXIII. Paper Production in Japan and the Rest of the Far East, 1950–53**

Million metric tons

| | *Japan* | | | *Rest of Far East* | | |
|---|---|---|---|---|---|---|
| | *Newsprint* | *Other paper and board* | *Total* | *Newsprint* | *Other paper and board* | *Total* |
| 1950 | 0.13 | 0.77 | 0.90 | 0.08 | 0.19 | 0.27 |
| 1951 | 0.17 | 1.03 | 1.20 | 0.08 | 0.29 | 0.37 |
| 1952 | 0.28 | 1.10 | 1.38 | 0.08 | 0.30 | 0.38 |
| 1953 | 0.41 | 1.35 | 1.76 | .. | .. | .. |

The rapid revival of the Japanese pulp and paper industry is indeed one of the most striking features of current developments in the Far East. Though cut off from the abundant pulpwood supplies in her former possessions (Manchuria, Korea, and Sakhalin Island), the pulp and paper output in Japan proper is already considerably higher than in the greater territory she governed before the war. Though her domestic fiber resources are strained, output continues to increase. In addition to pulping more and more hardwoods, the Japanese industry imports considerable amounts of pulp and makes increasing use of waste paper.

It is difficult to judge how much of apparent consumption of paper in the years 1950–52 represented extra demand generated by the Korean conflict and how much represented a permanent rise in domestic consumption proper. Official Japanese sources, however, are confident that demand will continue to expand rapidly as a result of the increase in population, rising living standard, and more extended use of pulp and paper products, and the official estimate of paper production in the next few years is given below:

**Table XXXIV. Estimated Production of Paper and Board in Japan, 1953–57**

| *Year* | *Thousand metric tons* |
|---|---|
| 1953 | 1760 |
| 1954 | 1960 |
| 1955 | 2130 |
| 1956 | 2320 |
| 1957 | 2520 |

* A portion of a survey prepared by the Food and Agricultural Organization in cooperation with the secretariats of the United Nations Educational, Scientific and Cultural Organization (UNESCO); the Economic Commission for Europe (ECE); and the Economic Commission for Latin America (ECLA). Because of its length, that part of the original report being published in *Tappi*, has appeared in two parts, the first being published in the June issue of *Tappi*. This is the second and concluding section. Those interested in the full report should refer to the publication with the same title, issued by the United Nations.

# Products for the paper industry

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This is indeed an ambitious program, representing (see Table XXXIII) almost a trebling of Japanese production between 1950 and 1957. The difficulties in the way of realizing this increase, principally that of obtaining the necessary raw material, are recognized by the Japanese; and, in fact, so far as is known, the corresponding program for pulp expansion has not yet been laid down. Moreover, since this program was announced the expanding Japanese economy has received a check. Low wages and the high cost of living have led to labor unrest. The government is pursuing a policy of deflation and the new budget foreshadows retrenchment in spending and tighter control over credit. Some slowing down of investment seems inevitable. For the purposes of this survey it has been asumed that domestic consumption will rise to 2.5 million tons by 1960–62, of which 600,000 tons will be newsprint; this is roughly three times the 1950–52 consumption of newsprint and twice that of other paper and board.

Most observers agree that paper and board consumption in China is likely to increase rapidly in the next decade. It is reported that in 1952 there were about 780 newspapers in the country with a circulation of 8 million and constantly growing. It is estimated that in the years 1935–37 China consumed about 230,000 tons of paper and board annually, of which 140,000 tons were imported; over two thirds of the domestic production consisted of handmade papers.

In recent years improvement seems to have been secured by concentrating on getting maximum output from the handmade establishments and by renovating existing plants, including the paper mills in Manchuria, rather than by erecting new plants. The low increase in production planned for 1953 (6% over 1952 as against 60% 1950–51 and 26% 1951–52) indicates that the limit of what can be achieved on the basis of existing mills and cottage industries is being reached, and that any substantial further rise must await the creation of new capacity. In Po I-Po's report on the 1953 state budget it was announced that total sales of the state trading organizations in 1952 totaled 158,000 tons. This figure probably includes imported as well as domestically produced paper; on the other hand, it most likely excludes a large proportion of handmade production, disposed of through local channels. The data available suggest that in the years 1950–52 production averaged about 155,000 tons annually and consumption 210,000 tons, including 90,000 tons of newsprint. It is estimated that by 1960–62 consumption will have reached 500,000 tons, or just over double the 1952 level, of which 180,000 will be newsprint. An increase of this magnitude would not be excessive in the light of present trends; such a level could not, however, be achieved unless both domestic capacity and the volume of imports were considerably expanded.

Consumption of paper and board in India averaged in 1950–52 nearly 260,000 tons, of which about 155,000 tons were domestically produced and the balance (including all the newsprint, about 60,000 tons) imported. This corresponds to a consumption of 0.7 kg. per inhabitant. The extensive program of industrial and educational development is expected to bring about a considerable rise in consumption, which is estimated by the FAO Survey Mission to reach 480,000 tons by 1962 and over 900,000 tons by 1972. For the purposes of the present survey it is estimated that consumption will rise to 430,000 tons by 1960–62:

**Table XXXV. Estimated Consumption of Paper and Board in India, 1960–62**

Thousand metric tons

| | *Newsprint* | *Other paper and board* | *Total* |
|---|---|---|---|
| Apparent consumption: | | | |
| 1950 | 75 | 172 | 247 |
| 1951 | 50 | 206 | 256 |
| 1952 | 54 | 218 | 272 |
| 1950–52 | 60 | 199 | 259 |
| Estimated 1960–62 | 120 | 310 | 430 |

Paper consumption in Indonesia, 85,000 tons before the war, was still in 1950 at 58,000 tons, well below the pre-war level. In the following 2 years it had risen to 80,000 to 85,000 tons and is estimated to have reached 110,000 tons in 1953. By 1960–62, it is estimated that it will have risen to 180,000 tons.

Similar trends are evident throughout Asia. Estimates of current and future consumption are summarized in Table XXXVI.

**Table XXXVI. Estimated Consumption of Paper and Board in the Far East, 1950–52 and 1960–62**

Thousand metric tons

| | *1950–52* | *1960–62* | *Percentage rise* |
|---|---|---|---|
| Japan | 1130 | 2500 | 121 |
| India | 258 | 430 | 66 |
| China | 210 | 500 | 138 |
| Indonesia | 74 | 180 | 143 |
| Philippines | 56 | 110 | 96 |
| Pakistan | 50 | 92 | 84 |
| Other countries | 147 | 238 | 62 |
| Total | 1925 | 4050 | 110 |
| Of which: | | | |
| Newsprint | 450 | 1070 | 138 |
| Other paper and board | 1475 | 2980 | 102 |

Again it should be remarked that consumption was rising rapidly from 1950 to 1952; thus the 110% increase over the 1950–52 average corresponds to a rise of only 83% over apparent consumption in 1952.

To produce 270,000 tons of newsprint and 1,230,000 tons of other paper and board in 1950–52 countries of the Far East consumed annually on average 1,015,000 tons of paper pulp.† Paper and board imports corresponded to 320,000 tons of pulp, bringing the pulp equivalent of total paper consumption up to 1,335,000 tons. Assuming that imports are of the same order of magnitude in 1960–62, the pulp equivalent of the estimated paper consumption will rise to 3,080,000 tons. Dissolving pulp requirements, 195,000 tons in 1950–52, are estimated to rise to 350,000 tons.

This indicates a rise in total pulp needs from 1,530,000 to 3,400,000 tons, i.e., by 122%. The rise in pulp requirements is steeper than that in paper consumption because the share of newsprint, in the manufacture of which there is less scope for using waste materials, is expected to increase considerably.

Most of the pulp used in Far Eastern countries was domestically produced, imports averaging in 1950–52 only 85,000 tons annually; of this 59,000 tons consisted of dissolving grades.

Resources of papermaking materials in the region are extensive and varied, though they are not evenly distributed. Forests cover some 450 million hectares, or 20% of the total land area. It has to be borne in mind, however, that only 214 million hectares, or less than half the total, are classed as accessible. Great tracts in the interior of China, along the Himalayan slopes from Pakistan to Burma, and considerable areas in Thailand and the outer islands of Indonesia consist of untouched forests. Of the accessible forests only 170 million hectares, about four fifths, are in use. Forty-four million hectares of accessible forest have not yet been exploited. Table XXXVII summarizes some of the main features of the forested area in the region.

Thus, in this most populous region of the world the area of accessible forest per inhabitant is very low—about one sixth of a hectare. This is about half the corresponding figure for Europe and one twelfth that for Latin America. Within the

† Excluding so far as the available data allow, pulps of other than wood fibers, e.g., bamboo, sabai grass, bagasse, etc.

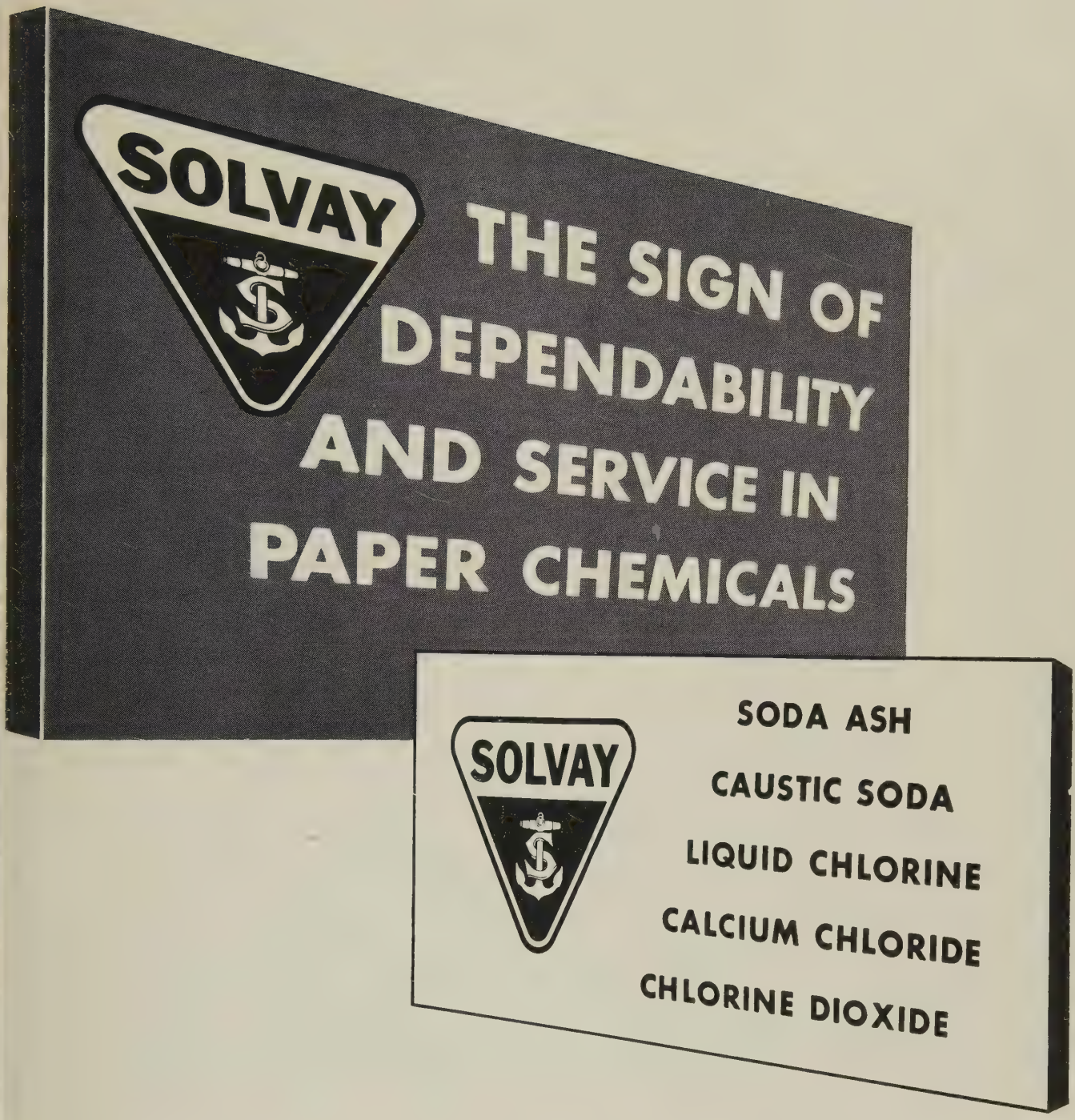


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**Table XXXVII. Forested Area in the Far East**

| Country | Forest area as percentage of total area | Accessible forests— Total, million hectares | Hectares per head | Conifers as percentage of forests in use |
|---|---|---|---|---|
| Regional total | 25 | 230 | 0.17 | 25 |
| Of which: | | | | |
| Burma | 58 | 25 | 1.35 | 4 |
| China | 9 | 28 | 0.06 | 84 |
| India | 22 | 17 | 0.14 | 5 |
| Indonesia | 64 | 11 | 0.16 | 1 |
| Japan | 62 | 22 | 0.26 | 42 |
| Pakistan | 3 | 3 | 0.03 | 20 |
| Philippines | 55 | 11 | 0.53 | 3 |
| Thailand | 77 | 16 | 0.83 | 1 |

region, area per inhabitant varies from 0.04 hectare in China and Pakistan to 8 in Burma and over 16 in Indonesian Borneo.

Broadleaved species predominate, and about three quarters of the forests in use consist of hardwoods. They are mainly dipterocarp forests, composed of a great number of species per hectare, of which often only a few are currently of commercial use. Burma, Indonesia, Malaya, and Thailand have large teak stands; in both China and Japan temperate hardwoods, such as oak, birch, and aspen, occur. Eucalyptus, as natural stands, are found only in Indonesia.

Conifers represent one quarter of the area of forests in use, and are unevenly distributed in the region. Spruce, fir, larch, pine, chamaecyparis, and cryptomeria are found in Manchuria, in the interior of China, in Japan, and West Pakistan. Elsewhere conifers are scarce and consist partly of artificial stands (*Pinus merkusii*, khasya, insularis, Agathis and Podocarpus).

Hitherto only in China and Japan have conifers been used for pulping, but clearly the region's coniferous resources represent a valuable potential for papermaking. And though temperate hardwoods are being used increasingly in Japan, the region's immense resources of tropical hardwoods have as yet not been tapped. Tests have established the pulpability of various species and mixtures, but in general the tropical hardwoods of the Far East have not attracted the same attention as in Africa and Latin America. This may be attributed to the fact that the region still contains considerable reserves of conifers, as yet unexploited, and immense resources of bamboo.

Bamboo is found all over the region in areas with high rainfall. It is estimated that there are some 400,000 hectares in Viet-Nam, 200,000 in Cambodia, and 100,000 to 110,000 in both Japan and Pakistan. In India, especially in the States of Madras, Assam, Orissa, Bombay, and Coorg, and in Burma there is sufficient bamboo to support sizable pulp industries. Bamboo is today India's most important papermaking material, while China, which has made paper from bamboo for many centuries, makes use of it on an industrial scale at plants in Shanghai and in the province of Fukien.

Many other potential papermaking materials occur locally, as, for example, reeds and grasses in East Pakistan, sabai grass in several Indian States, abaca in the Philippines, and the Nipa water palm in tropical zones.

Though the region as a whole has resources capable of supporting a pulp industry many, many times its present size, the raw material supply in certain countries already gives cause for anxiety.

One of the most serious problems is that faced by Japan, where the forest area was reduced by 45% and standing stock by 33% as a result of territorial losses after the war. Most serious was the loss of the forests of Southern Sakhalin, which before the war supplied the pulp industry with 56% of its raw material. Although 62% of the land area is forested (a higher percentage than in Sweden), because of the dense population forest area per inhabitant is only 0.26 hectare, or lower than the European average. Of the 22.6 million hectares of forest, only 800,000 are classed as inaccessible. Thirty-one per cent of the forests in use consist of pure conifers, 45% of pure broadleaved stands, and the rest, apart from 7% open areas, of mixed woods.

The volume of standing timber, however, is low, only 1574 million cu. meters, or 72 cu. meters per hectare. The figure for coniferous stands only 85 cu. meters per hectare, compares unfavorably with that in Scandinavia (about 100, with a less favorable climate) and with that in the Central European Coniferous Belt (150 to 250). An indication of the wood supply problem is given by the fact that annual cut in 1948–52 averaged 59 million cu. meters, against an estimated allowable cut of 46.5 millions. An ambitious afforestation program cannot afford relief for many years, and efforts are concentrated on bringing the few inaccessible forests into use, which is proving expensive, and on pulping more and more hardwood. In 1952, hardwood accounted for only 3% of the 5 million cu. meters of pulpwood utilized. More than half the total cut in Japan is used for charcoal and as fuelwood, and though the proportion is being reduced, releasing quantities for industrial use, Japan's limited fuel resources set a limit to what can be achieved in this direction.

Nevertheless the pulp and paper industry continues to expand. Paper and board capacity in 1952 was reckoned at 1,940,000 tons and was expected to rise to 2,060,000 tons at the end of 1953, the increase including five additional newsprint machines with an aggregate annual capacity of 36,000 tons.

**Table XXXVIII. Capacity and Production of Japanese Paper Industry, 1952–53**

Million metric tons

| | Newsprint | Other paper and board | Total |
|---|---|---|---|
| 1952 capacity (end year) | 0.49 | 1.45 | 1.94 |
| 1952 production | 0.28 | 1.10 | 1.38 |
| 1953 capacity (end year) | 0.53 | 1.53 | 2.06 |
| 1953 production (est.) | 0.43 | 1.28 | 1.71 |

A similar rapid development is taking place in pulping capacity. Completions during 1953 included, besides a 20,000-ton high-alpha sulphite plant, two bleached sulphate mills with a total capacity of 30,000 tons, while among the mills at present under construction may be noted four new semichemical pulp mills with a total capacity of 42,500 tons.

It is difficult to gage future developments. Prevailing anxieties would suggest that expansion must slow down later in the decade. The achievement of the paper production targets mentioned earlier would seem to depend on securing steadily increasing quantities of pulpwood and/or pulp from abroad. This would presumably enable Japan to become an important exporter of paper and board to other Asian markets; so far she has not succeeded in restoring this trade to its prewar level. If raw material supplies do limit expansion, then it is likely that rising domestic requirements will, as today, absorb nearly all her own production. The account of Japan's own forest resources above will have made it clear that future increases in the supplies of domestic pulpwood are likely to be attended by rising costs; these would lower the competitive power of finished paper products in foreign markets.

In China, however, raw material resources would not seem to impose any limit to expanding pulp output. Today extensive use is made of bamboo, and bagasse is being successfully used in Szechuan. Moreover, it has been established that in many provinces the forest reserves are much greater than had been assumed. Increasing coal output and improved communications are facilitating the diversion of fuelwood to industrial use.

As mentioned earlier, it seems likely that output is reaching the maximum possible on the basis of existing capacity, and that any further increase will be contingent on the building of new mills. Construction began this year on two important

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projects, a new paper mill in Kiamusze, Northwest China, and a considerable expansion of the existing Kwantung paper mills. By 1956, the latter is expected to provide, besides a substantial increase in newsprint output, 10,000 tons of chemical pulp for the use of other paper mills. Nothing is known of future plans, but the current emphasis on developing heavy industry, transport, and communications would suggest that this region, for the time being, rely largely upon imports to meet her rising requirements.

Though India today is largely self-sufficient in paper and board (excepting newsprint) industrial development and rising literacy call for a more ambitious development of pulp and paper production than is at present planned if expected additional requirements are to be fully met. Materials are at hand in the shape of bamboo and bagasse and in certain areas mixed hardwood forests could be utilized. In the long term the coniferous resources of the Himalayas will become important as a source of mechanical pulp, while there is scope for developments based on plantations of eucalyptus and other species. The new integrated 30,000-ton newsprint mill at Nepanagarh, based on bamboo and salai wood, is expected to come into production this year, while several other paper and board mills, based on bamboo and bagasse, are planned, as well as some extensions to existing plants. Preliminary investigations suggest that there is sufficient fibrous raw material in the country to cover needs in the next 20 years, save for newsprint. An adequate indigenous production of newsprint would seem to depend on the possibilities of utilizing bagasse, on the plantation of suitable species, or on the successful exploitation of the Himalayan conifers. The last of these would not seem to be economic at the present time.

In most other Asian countries, where consumption is low, new developments have to take into account the size, as well as the nature and location, of the domestic market. On the other hand, the smallness of the market may be partly offset by geographical considerations. The Philippines, for example, with a consumption of only 50,000 to 60,000 tons, is estimated, by virtue of its position, to enjoy a "geographical" protection of 15 to 20%. Here two small mills are already in

**Table XXXIX. Pulp and Paper Mills Under Construction or Likely to Be Constructed During the Current Decade in the Far East**

Thousand metric tons per annum

| Country | Site | Capacity: Newsprint | Capacity: Other papers and boards | Capacity: Mechanical pulp | Capacity: Chemical pulp | Capacity: Dissolving pulp | Process[a] | Raw material | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Far East (excl. China and Japan) | | | | | | | | | |
| Burma | Arakan area | .. | 12 | .. | 30 | .. | 4 | Bamboo | 18,000 tons of pulp for export |
| India | Nepanagarh | 30 | ... | 18 | 12 | .. | 1 + 4 | *Boswellia serrata* and bamboo | Under construction |
| | Sirpur | .. | 10 | .. | 8 | .. | 4 | Bamboo | Extension project under construction |
| | Bhadravati | .. | 4 | .. | 4 | .. | 4 | Bamboo | Extension project under construction |
| | Dalmianagar | .. | 13 | .. | 12 | .. | 4 | Bamboo, bagasse | Extension project |
| | Saharanpur | .. | 2 | .. | 2 | .. | 3 | Sabai grass | Extension project |
| | Jumnanagar | .. | 6 | .. | 6 | .. | 3 | Sabai grass | Extension project |
| | Brajrajnagur | .. | 28 | .. | 25 | .. | 4 | Bamboo | Extension project |
| | Vyuuru, Madras | .. | 5 | .. | 5 | .. | 5 | Bagasse | Under construction |
| | West Bengal | .. | 3 | .. | 3 | .. | (?) | (?) | ..... |
| | Utram, Bombay | .. | 3 | .. | 3 | .. | 7 | Bamboo | ..... |
| | Bombay | .. | 3 | .. | ... | .. | .. | Imported pulp | Glassine papers |
| | Hyderabad | .. | 15 | .. | 15 | .. | 4 + 6 | Bagasse | ..... |
| | Coorg | .. | 15 | .. | 15 | .. | 4 | Bamboo and mixed woods | ..... |
| | Assam | .. | 15 | .. | 15 | .. | 1 + 4 | Bamboo and *Pinus khasca* | ..... |
| Indonesia | Northern Sumatra | .. | 18 | .. | 18 | .. | 4 | *Pinus merkussi* | Unbleached pulp |
| | Central Java | .. | 12 | 4 | 8 | .. | 1 + 4 | *Pinus merkussi* and *Agathis loranthifolia* | Bleached pulp |
| | Northern Sumatra | .. | 12 | .. | 12 | .. | 4 | *Pinus merkussi* | For completion by 1963 |
| | East Java | .. | 12 | .. | 13 | .. | (?) | Bamboo | For completion by 1963 |
| Pakistan | Chandraghona | .. | 30 | .. | 30 | .. | 4 | Bamboo | Under erection |
| | Rahwali | .. | 8 | .. | 8 | .. | 6 | Straw | Under construction |
| | Nowshera | .. | 8 | .. | 8 | .. | 7 | Grass | Under construction |
| | Khulna | 30 | ... | 20 | ... | .. | 1 | *Excaecaria agallocha* | Chemical pulp from extension Chandraghona |
| Philippines | Davao | .. | ... | .. | 20 | .. | 3 | Abaca waste | ..... |
| | Davao | .. | ... | .. | 30 | .. | ... | Hardwood sawmill waste | ..... |
| | Northern Mindanao | .. | 25 | .. | 25 | .. | ... | Hardwood waste | ..... |
| | Manilla | .. | 45 | .. | ... | .. | ... | Locally produced pulp | ..... |
| Thailand | Kanburi | .. | 10 | .. | 10 | .. | ... | Bamboo | Extension project |
| Viet-Nam | Dran | .. | 18 | .. | 18 | .. | 1 (?) + 4 | *Pinus khasya* | ..... |
| Total | | 60 | 332 | 42 | 355 | .. | | | |

[a] (1) Mechanical process; (2) sulphite process; (3) soda process; (4) sulphate process; (5) caustic soda-chlorine process; (6) mechano-chemical process; and (7) semichemical process.

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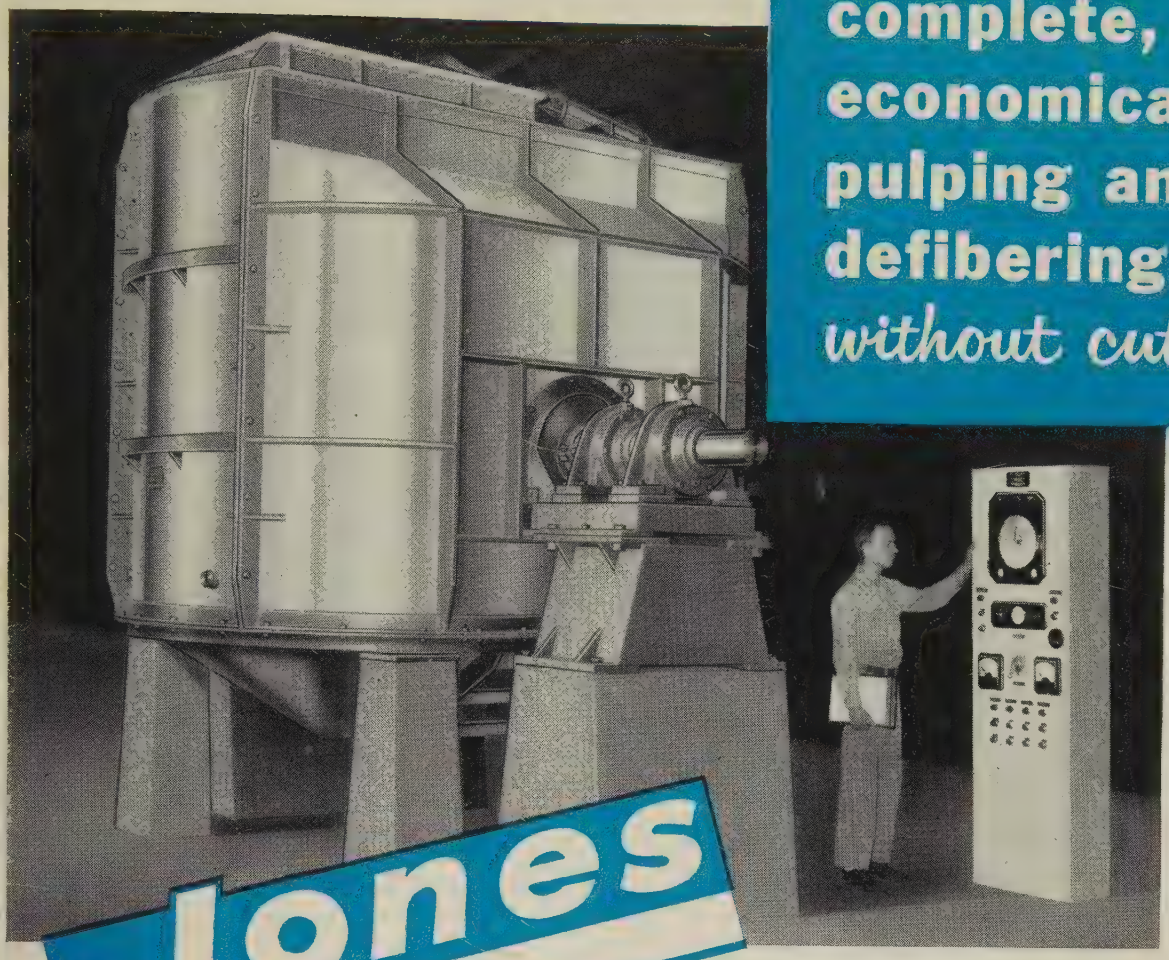

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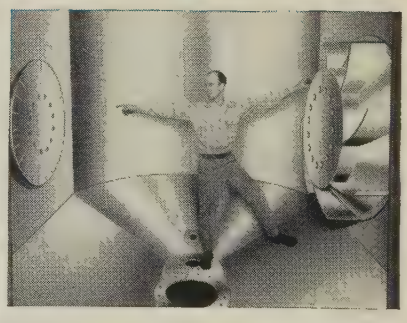

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operation, one using bagasse, the other imported pulp. The most promising of the various projects discussed is a pulp mill at Davao, using abaca waste. A large part of the Benguet pine resources, which might be considered for pulping, is already taken up by sawmill concessionaires. Apart from the Davao project mentioned, most of the other schemes under discussion require further investigation as to markets and the availability and suitability of resources.

Indonesia, with 62% of its land area forested—1.2 hectares per inhabitant—would seem to be well endowed. Again, however, the distribution is unfavorable, since Java, with a population of 55 millions, has only 0.012 hectare per head if the protective forests are excluded. More than two thirds of the Indonesian forest resources consist of tropical rain forests of mixed hardwoods. There are, however, important stands of both *Agathis loranthifolia* and *Pinus merkussii*, fast-growing conifers which offer good pulping prospects. Bamboo grows well in Indonesia; since however, it is at present entirely grown by farmers for their own use (building materials, etc.) commercial plantations would be required to provide material for pulping. Some 10,000 to 20,000 hectares have been earmarked for this purpose in East Java. Though rice is the most important food crop, the two existing mills, which operate on rice straw, already have difficulty in securing supplies; further developments based on rice straw would call for a fundamental change in agricultural methods.

Low consumption and unsettled political conditions hamper the development of pulp and paper production in the associated states of Indochina. Nearly all of the 28,000 tons total is consumed in Viet-Nam, consumption in Cambodia and Laos together amounting only to 540 tons. All supplies have been imported since the destruction of the Vietri mill in 1945. Apart from the immense tropical hardwood resources, there are extensive stands of *Pinus khasya*, while bamboo grows freely in many regions.

In Burma, Thailand, and Pakistan, as already mentioned, there are considerable reserves of bamboo. The problem, however, is to insure accessible supplies in sufficient quantity in locations suitable for siting pulp mills. It must not be overlooked that throughout the Far East bamboo serves as poor man's timber, so that the diversion of many accessible stands to industrial uses cannot be contemplated.

Details of all pulp and paper expansion plans in the Far East region (excluding Japan and China) are given in Table XXXIX. Developments in China and Japan have been omitted from this table partly because less detail is available concerning future plans, but mainly because, as the earlier discussion has shown, both these countries present special problems in relation to their future domestic supply/demand position. It is therefore possible only to draw general conclusions concerning the extent to which these countries will add to or be able to reduce the regional deficit in the coming decade.

Some of the projects listed are under construction; others are still at the discussion stage. Some are unlikely to be initiated during the period covered by this survey of prospects, e.g., it is doubtful whether more than two of the four projects listed for the Philippines will be embarked upon before 1960–62.

However, if all these projects were carried out, they would add about 400,000 tons to the region's pulping capacity and about the same amount (including 60,000 tons of newsprint) to the region's paper and board capacity. This compares with an expected increase in requirements during the decade of about 465,000 tons. As Table XL shows, the expansion would just about keep pace with the rise in demand for paper and board other than newsprint; it would entail a deficit in newsprint 80,000 tons greater than at present.

This table assumes that imports of paper and board into the region will continue at their current level. The final column refers not to total deficit, but to the increase in deficit. It has also to be borne in mind that the estimate of additional capacity set out in the preceding table is an exceedingly optimistic one. The expected increase in the regional deficit in Table XL may therefore well be an underestimate. To it must be added increasing import requirements in China, in the light of our discussion of prospects in that country. Nor is there any firm promise of the regional deficit being reduced by any substantial net contribution from Japan.

Our brief review of prospects in the Far East region has therefore led us to the following conclusions. Demand for paper and board will continue to rise rapidly throughout the region. Coniferous resources, though scattered, are by no means negligible, and there are ample supplies of other materials suitable for pulping, though they are not evenly distributed. Projects at present contemplated in the region (excluding China and Japan) would seem adequate to satisfy the expected increase in demand for paper and board, but would leave the region with an increasing deficit in newsprint. It therefore seems urgent to consider whether there are any additional prospects of developing the region's newsprint capacity. Japan is likely to continue to be the most important producer and consumer of paper products in the region, but her raw material difficulties, coupled with the rate at which domestic demand is rising, seem likely to limit her possibilities of reducing the deficit elsewhere in the region. Industrial and cultural developments in China suggest that her importance as a market for pulp products will increase in the next decade.

### *Near and Middle East*

This region† has a population of just under 80 millions. Most of its people—between 75 and 90% in most countries—are engaged in agriculture and animal husbandry. Save for petroleum, industry is little developed, and many branches have not passed beyond the handicraft stage. The literacy rate is very low, estimated at 15 to 25%. It is thus not surprising that paper and board consumption is small, a mere 100,000 tons for the whole region, and consumption per inhabitant, at 1.3 kg., among the lowest in the world.

Newsprint consumption, about 24,000 tons in 1950–52, has more than doubled as compared with prewar; the rise in consumption of other categories has been much less. Turkey

† Comprising for the purposes of this Survey. Aden, Afghanistan, Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Trucial, Oman, Saudi Arabia, Syria, Turkey, and Yemen.

**Table XL. Estimated Increase in Paper Production Capacity and Demand in the Far East (Excluding China and Japan) 1950–52 to 1960–62**

Thousand metric tons

| *Category* | *Present consumption* | *Present imports* | *Present regional production* | *Estimated additional regional capacity* | *Estimated increase in demand by 1960–62* | *Increase in deficit over 1950–52* |
|---|---|---|---|---|---|---|
| | Thousand metric tons | | | | | |
| Newsprint | 160 | 145 | 15 | 60 | 140 | 80 |
| Other paper and board | 405 | 230 | 175 | 332 | 325 | −7 |
| All paper and board | 565 | 375 | 190 | 392 | 465 | 73 |

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**Table XLI. Forest Resources in the Near and Middle East**

| | *Woodlands as percentage of total area* | *Accessible forests* | | *Forests in use* | |
|---|---|---|---|---|---|
| | | *Total area, million hectares* | *Hectares per head* | *Total area, million hectares* | *Percentage of conifers* |
| Middle and Near East | 6 | 29.3 | 0.4 | 28.8 | 22 |
| Of which: | | | | | |
| Turkey | 14 | 10.3 | 0.5 | 10.3 | 56 |
| Iran | 12 | 16.0 | 0.8 | 16.0 | .. |
| Saudi Arabia and Yemen | .. | [a] | ... | [a] | .. |
| Rest[a] | 2 | 3.0 | 0.1 | 2.5 | 22 |

[a] Afghanistan, Cyprus, Jordan, Iraq, Israel, Lebanon, and Syria.

is the largest consumer with 44,000 tons (of which 15,000 was newsprint); Israel comes next, with 19,000 tons, and is followed by Iran with 14,000 tons. No other country consumes as much as 10,000 tons.

The region as a whole lacks both the capital and skills to achieve a rapid transformation of the pattern of economic life; nevertheless steady changes are taking place, prompted in part by external aid in which several United Nations agencies are playing a prominent part. Improved communications, irrigation projects, advances in public health, rising literacy will have a direct or indirect impact on the demand for paper. Efforts to improve the quality of exports of agricultural products will increase the demand for packaging grades. It is estimated that demand will rise to 150,000 tons by 1960–62, of which newsprint would account for 40,000 tons.

Today the region imports three quarters of its paper supplies. Apart from a small output of paper and board in Israel and Iran (based on waste paper), production is confined to Turkey, where output in 1950–52 averaged 23,000 tons, including 5000 tons of newsprint.

Much of the region can justly be described as a series of fertile islands in a desert sea. In many countries forest resources are negligible, as Table XLI shows.

Woodlands cover some 33.5 million hectares, that is to say, only 6% of the total land area, the proportion being lower than in any of the regions we have considered. Vast areas in the subdesert and desert regions of Arabia, Syria, Iraq, and the high plateau of Iran are completely treeless. The entire region suffers from a chronic shortage of wood. Only in Cyprus (18%), Turkey (14%), and Iran (12%) does the forested area exceed 10% of the total land area. If Turkey and Iran are excluded, the area of accessible forest per inhabitant is only 0.02 hectare. For the region as a whole the figure is 0.4 hectare. Conifers are mostly concentrated in the temperate and mountainous zones of Turkey, Lebanon, Syria, Cyprus, and Afghanistan.

In spite of the fact that the topography of the region is often rough, over 85% of the forests are accessible and nearly all the accessible forests are in use. The exploitation in a large part of these forests, however, is confined to charcoal-burning. The only sizable virgin forests are found in Iran (about 2 million hectares of temperate and subtropical hardwoods on the northern slopes of the Elbruz mountains) and in the mountains of Turkey and Iraq.

Low as are these figures of forest area, they nevertheless exaggerate the wealth of the region's resources. Many of the stands, both coniferous and broadleaved, are degraded by overgrazing, charcoal burning, lopping and fire, and are therefore thinly stocked with a very low volume of standing timber per hectare and a low annual growth. Considerable areas described as forest in Iran, Turkey, and Iraq are no more than brushland and coppice.

As in many other thinly forested areas, trees outside the forest assume a certain importance and a number of countries, notably Iran, Iraq, Israel, Jordan, and Syria, have irrigated plantations of poplar and eucalyptus providing constructional timber for local use and also, in the case of Turkey, pulpwood.

In most countries the importance of sound forest management and bold afforestation schemes is now recognized. But it must be noted that in this region, perhaps more than anywhere else in the world, priority must be accorded to the protective role, rather than the industrial role, of new plantings.

Of Turkey's 10.5 million hectares of forest, more than 6.5 millions consisting of degraded coppices and high forest so that the area capable of effective exploitation is less than 4 million hectares. The most valuable reserves lie in the mountain valleys of the Black Sea region, where dense spruce stands occur. There are useful stands of pine in Central Anatolia, but the pine forests of the Mediterranean region have been seriously damaged by overgrazing.

Though Iran records 16 million hectares of accessible forest, only 3 million hectares can truly be regarded as forest. Most of the rest consist of thin brushlands of Persian oak, yielding little but wood for fuel and charcoal. The best reserves lie in the province of Masenderan along the Caspian Sea. Woodlands have entirely disappeared from the high plateau, but nearly every village has its irrigated poplar plantation.

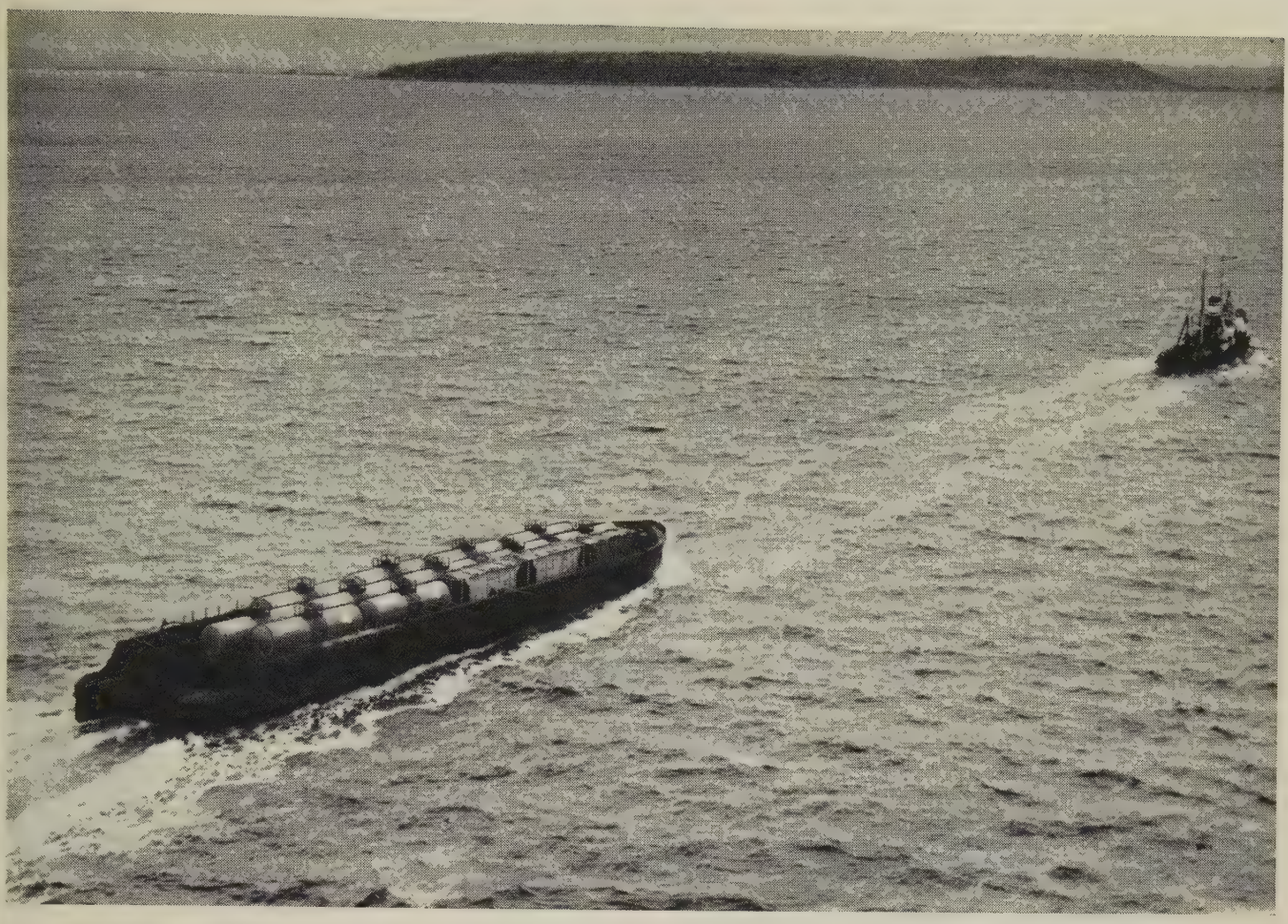
In Saudi Arabia and Yemen, forests scarcely exist, but again some villages have plantations of poplar and eucalyptus. Elsewhere the region scattered pockets of valuable timber, mostly broadleaved, occur, for example in Cyprus, Lataki (Syria), and the interior valleys of Iraq. Conifers are scarce, but Aleppo pine is found in Jordan, Israel, and Syria, junipers in the dryer zones of many countries, cedar in Lebanon, Syria, and Cyprus, various pines in Cyprus, and deodar pine, blue pine, Himalayan spruce, and larch in Afghanistan.

Nor does the region contain any great wealth of paper-making fibers other than wood. In few places do agricultural

**Table XLII. Pulp and Paper Mills Under Construction, or Likely to Be Constructed During the Current Decade in the Near East and Middle East**

Thousands metric tons per annum

| *Country* | *Site* | *Newsprint* | *Other paper and board* | *Chemical pulp* | *Process* | *Raw material* | *Remarks* |
|---|---|---|---|---|---|---|---|
| Israel | Hadera | 3 | 19 | .. | (?) | (?) | No details available |
| Turkey | Izmit | ... | 22 | 20 | (?) | Conifers and straw | Extension project |
| | Smyrna-Manisa | ... | 12 | 12 | Sulphate | Beech (or pine) and straw | ..... |
| Iraq | Basra | ... | 12 | 12 | Sulphate | Reeds | ..... |
| Total: Near and Middle East | | 3 | 65 | 44 | | | |



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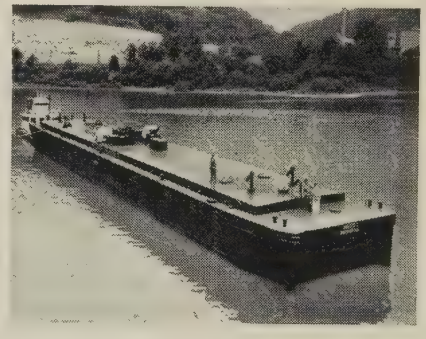

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Table XLIII. Estimated Increases in Paper Capacity and Demand in the Near and Middle East, 1950–52 to 1960–62

Thousands of metric tons per annum

| Category | Imports 1950–52 | Production 1950–52 | Estimated increase in capacity to 1960–62 | Estimated increase in demand to 1960–62 | Estimated increase in deficit |
|---|---|---|---|---|---|
| Newsprint | 18 | 5 | 3 | 20 | 17 |
| Other paper and board | 56 | 22 | 65 | 29 | −36 |
| Total | 74 | 27 | 68 | 49 | −19 |

wastes arise in quantities sufficient to contemplate their industrial use. One important resource, however, of which further mention is made below, lies in the reeds and grasses of the lower courses of the Tigris and Euphrates rivers.

The meagerness of the region's fibrous resources, and the fact that many of the national markets for paper are still very small, has limited discussion of possible plans for adding to the region's capacity to a handful of projects. These are listed in Table XLII.

The capacity of the only existing mill in Turkey, at Izmit, was recently increased from 25,000 to 38,000 tons. It has been proposed that further extensions be undertaken, bringing capacity up to 60,000 tons, a figure which for site reasons would represent the maximum upper limit. The only other projects so far discussed in Turkey would be sited at or near Smyrna and, like the Izmit extension, would be based on conifers and straw.

Though Iraq has negligible forests resources, the southern tracts of marshes bear limitless supplies of reeds, some of which are suitable for pulping. Spot counts suggest that there exists an area of 400,000 hectares of exploitable marshland bearing about 3 million tons of *Phragmites communis*. The 12,000-ton mill contemplated would produce cellulose papers only. In the long term the production range could be increased by groundwood from domestic poplar. Since Iraq consumption today is only 5000 to 6000 tons, only part of which consists of papers which the planned mill could produce, this project, if proceeded with, would have to rely on the export market for the disposal of much of its output.

Construction has started in Israel of a 22,000-ton mill at Hadera, north of Tel-Aviv; it is intended that production at this plant, which will operate partly on imported pulp, shall include 3000 tons of newsprint.

Provided all these projects are completed, nearly 70,000 tons will be added to the region's paper and board capacity.

It would appear that import requirements would diminish by about 20 thousand tons in the course of the decade, an improvement in local supplies of paper and board more than offsetting the increasing deficit in newsprint. It should not be overlooked, however, that one reason for the low levels of consumption prevailing in this region is the inability of many countries to spare foreign currencies for paper and board imports. Thus the projects in Turkey and Israel, and to a lesser extent that in Iraq, are likely to find their output readily absorbed by the domestic market so that the new production will lead to a less than proportionate displacement of imports. Moreover, the region's pulp deficit would increase slightly.

Throughout the Near and Middle East region the level of paper consumption is low, and though increases may be expected during the current decade aggregate demand will continue to be small in relation to the world total. Supplies of fibers suitable for papermaking are very limited. Expansion plans now under discussion or in course of construction would leave the region with an increasing deficit of newsprint, though for other categories of paper and board import requirements may undergo little change. The region will thus continue to be largely dependent on imports of paper and pulp, but incentives for further development of production within the region will be limited until national markets have increased beyond their present size.

*Africa*

The 200 million or so inhabitants of this region consume about 450,000 tons of paper and board annually: 53% of the total is consumed in the Union of South Africa; Egypt, the next largest consumer, accounts for another 16%; Algeria, Tunesia, and French Morocco between them consume about 15% of the total. For the region as a whole, consumption per head is about 2.2 kg. In South Africa, it is 33 kg.; in Egypt and French North Africa it is between 3 and 3.5 kg.; in the rest of Africa it averages only half a kilogram.§

Africa thus presents, perhaps more than any other region, extreme contrasts in levels of paper consumption, reflecting disparities in the economic and cultural development of different parts of the continent.

Newsprint accounts for about 80,000 tons of the total regional consumption. All newsprint is imported from other regions, as is three quarters of the supply of other categories of paper and board. In addition a small quantity of pulp is imported to supplement domestic production.

Advancing industrialization in South Africa, together with moves toward self-government accompanied by development projects and rising literacy elsewhere in Africa, is expected to bring about a rapid increase in demand, which is estimated to reach 710,000 tons in 1960–62, including 150,000 tons of newsprint.

For the most part local markets in the region are small, usually too small to support mills of an economic size. Of the 90,000 tons of paper and board produced on average in 1950–52, over 50,000 tons was manufactured in the Union of South Africa, and practically all the rest in Egypt and French North Africa.

The two most striking features of the pulp and paper situation in Africa today are, first, the relative scarcity of suitable raw materials in South Africa, which today produces and consumes more than half the continent's total, and, second, the interest being taken by metropolitan countries in the possibilities of developing new sources of pulp in their overseas African territories.

The main facts about Africa's forest resources are summarized in Table XLIV:

The first outstanding fact to note is that though 27% of the continent's land area is forested, in North Africa and in the Union forests cover only 1% of the land area. Of the tropical forests of West and Equatorial Africa, which account for more than half of all the continent's forests, only one fifth are accessible, and only 10% in use.

Over much of the continent the very term "forest" bears a meaning strange to one accustomed to the forests of the temperate zones. Large areas are covered with wooded savannah, given way to shrub and thorny formations. These very open and scattered forests—for as forests they are usually classified—have a low economic value. Standing stock is typically between 10 and 50 cu. meters per hectare, with annual growth often less than 1 cu. meter per hectare. These

§ This estimate may be slightly on the low side. Many of the independent African countries, as well as nearly all the dependent territories, have a very low consumption, wholly met by imports. The published trade statistics seldom give detailed paper import figures. Moreover, a substantial part of paper consumption is met by imports of paper and board manufacturers which, so far as possible, have been omitted from the figures quoted above.

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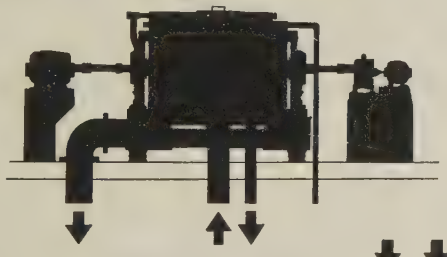

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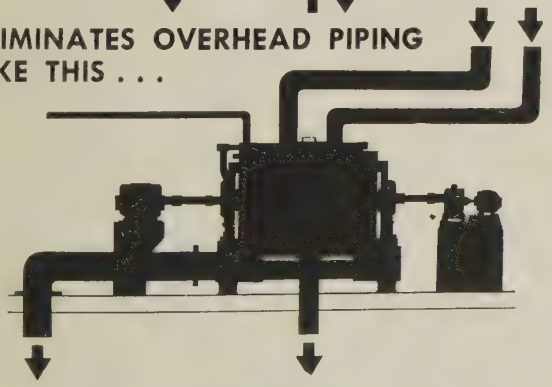

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**Table XLIV. Forest Resources of Africa**

| | Forested area | | Accessible forests | | Forests in use | |
|---|---|---|---|---|---|---|
| | *Total, million hectares* | *Percentage of land area* | *Total, million hectares* | *Hectares per head* | *Total, million hectares* | *Of which conifers, %* |
| Africa | 801 | 27 | 282 | 1.4 | 115 | 2.4 |
| Of which: | | | | | | |
| North Africa | 8 | 1 | 5 | 0.1 | 4 | 33.8 |
| Union of South Africa | 1 | 1 | 1 | 0.1 | 1 | 18.4 |
| West-Central Africa | 478 | 44 | 108 | 0.9 | 49 | ... |
| Rest | 314 | 30 | 168 | 2.6 | 61 | 0.01 |

open formations occur in each of the regions distinguished, but especially in that described as the "rest of Africa," which includes the whole of East Africa, Sudan, and Rhodesias, etc.

Thus, with immense treeless tracts in the north and south of the continent, and a large proportion of the accessible forests consisting of the formations just described, little significance can be attached to the fact that the area of accessible forest per inhabitant (1.4 hectares) is above the world average and five times that in Europe.

Conifers constitute a very small percentage of the total area of forests in use; as natural stands they are found only in mountainous zones or in the Mediterranean vegetation zone.

The forests of the Union of South Africa are mainly situated in the subdesert vegetation zone. The indigenous forests consist almost entirely of slow-growing hardwoods. But, since 1880, artificial forests of quick-growing species have been systematically planted; progress has been particularly rapid during the last decade. By 1950, artificial stands covered 670,000 hectares, including 220,000 hectares of conifers. Among the hardwoods planted, the most important are eucalyptus (150,000 hectares), acacia, or wattle (250,000) and poplars (13,000). Growing stock on the coniferous plantations is estimated at 22.5 million cu. meters, or 100 cu. meters per hectare. Table XLV shows the age distribution in these coniferous plantations:

**Table XLV. Age Distribution of South Africa's Coniferous Plantations**

| *Age group* | *Percentage of the total volume of conifers* |
|---|---|
| 10 years and under | 20 |
| 11 to 20 years | 35 |
| 21 to 30 years | 35 |
| Over 30 years | 10 |

In West and Central Africa dense evergreen and deciduous tropical formations predominate, part of them (Gold Coast, Dahomey, Nigeria, Belgian Congo, French Cameroons, and French Equatorial Africa) belonging to the rain forest type. These forests have a very mixed composition and frequently only a few species are used commercially. In the rain forests growing stock per hectare is very high, varying from 400 to 1000 cu. meters. Growth is typically around 15 cu. meters per hectare, but log extraction in these areas being exploited may amount to only 1 or 2 cu. meters per hectare. The whole of this immense region is completely devoid of conifers, either as plantations or in natural stands.

Two thirds of the forests in use in the semi-arid Mediterranean vegetation zone of North Africa are broadleaved (mainly oak species, such as cork oak and holm oak) but conifers, often in pure stands, are found in the high plateau (Atlas cedar, Aleppo pine, thuya, and cypress) and in the steppe forests (junipers).

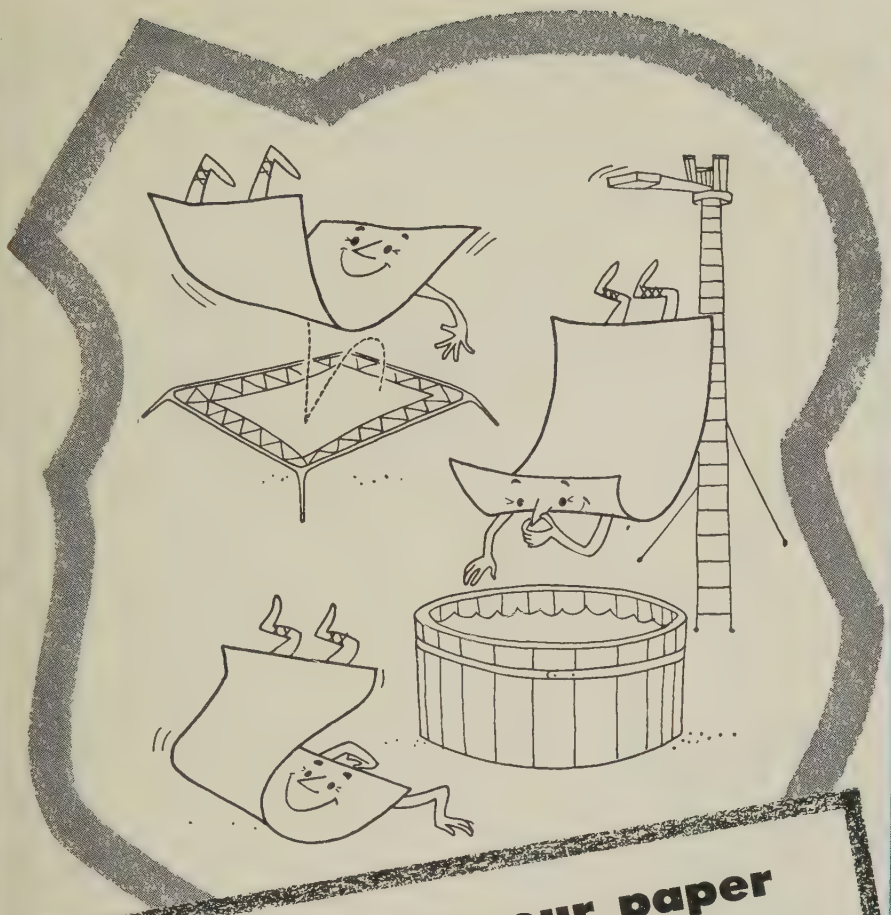
Elsewhere in Africa the forests are mainly situated in the tree-savannah vegetation zone, with an annual rainfall of not more than 1000 mm. and a long dry season of 7 to $8^1/_2$ months. These grassy, open forests give way to thorn and shrub in regions where the rainfall drops below 500 mm. a year. Only in the mountainous regions (Ethiopia, Kenya) do important areas of conifers (cedar, Podocarpus) appear.

We have noted the strenuous efforts that are being made in South Africa to remedy the lack of forest resources by additional pine and eucalyptus plantations. The four mills operating today are based on plantation pine, eucalyptus, wattle, and imported pulp, together with a very high rate of waste paper usage. Indeed, waste paper has been described as South Africa's "no. 1 papermaking material." One of South Africa's greatest potentials is cereal straw, as yet hardly exploited; apart from the difficulties of collection, present agricultural methods do not free large quantities for industrial use. The sugar-growing area of Natal offers further possibilities; one bagasse-based project, a 6000-ton paper and board mill, started production last year at Felixton, and plans have been completed to double its capacity. Construction has also started in Natal of a 36,000-ton dissolving pulp mill (mainly for export) based on eucalyptus plantations. Though the pulp and paper industry is developing rapidly in South Africa, its future rate of expansion will be governed mainly by the progress of pine and eucalyptus plantings.

North Africa is similarly handicapped, as Table XLIV shows, by lack of forest resources. Egypt, the largest consumer, is anxious to develop indigenous production and the Permanent Council for the Development of National Production has called for tenders for the construction of a 30,000-ton mill. Such a mill would have to be based on agricultural residues—cereal straw, cotton stalks, and bagasse, with perhaps some papyrus and bamboo. The cellulose content of agricultural by-products becoming available annually is estimated at over 3 million tons.

French North Africa has long exported considerable quantities of esparto to Europe, mainly to the United Kingdom, whose annual imports of esparto have averaged 300,000 tons in normal times. There is already a paper industry in North Africa, based on esparto, and additional mills for the manufacture of esparto pulp for export are planned. Esparto resources in Algeria, Tunesia, and Morocco are estimated at 7.2 million hectares, with a theoretical yield of 2.2 million metric tons of dry material. Actual production, however, is only about a quarter of this figure, since vast areas lie beyond the reach of present road and rail communications and there are limits to the labor available for harvesting. Furthermore, steps have been taken to prevent exhaustion in the more accessible areas. In recent years, Libya has developed an important export trade in esparto. The crop averaged 25,000 tons in the years 1948–50 and it is estimated that good management and improved communications would enable the harvest to be easily doubled. The material resources of North Africa are today being supplemented by plantings of eucalyptus and poplar.

By far the most important reservoir of fibrous material in the African continent is the immense belt of tropical hardwood forests of West and Central Africa—French West and Equatorial Africa, Nigeria, the Gold Coast, Belgian Congo, Angola, etc. Though these forests have during the last few decades been yielding a steadily increasing flow of saw and veneer logs, mainly for export, it is only since the war



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that they have come to be considered seriously as a possible source of pulp. The problems attached to their utilization are well known.

Some of these problems stem from the nature and occurrence of the material itself. Pure stands are seldom encountered in tropical forests. An area of several thousand hectares may contain as many as 200 different species, though in general not more than 20 will predominate. Almost invariably, therefore, any plan for utilizing tropical forests for pulp must envisage pulping mixtures of hardwoods. The species met with may vary considerably in specific gravity, from 0.2 to 1.2 (oven-dry weight) in some cases. This fact determines the pulping techniques which may be applied. All hardwoods are short fibered, and this restricts their papermaking versatility unless the resultant pulp can be mixed with long-fibered pulp. The general level of economic development in the tropics is usually low, so that installation and maintenance costs, skilled labor, transport and chemical costs may be high, perhaps so high as to offset the cheapness of the raw material. Finally, in tropical Africa local markets are small, so that any project of an economic size must, at this stage be conceived primarily in terms of export possibilities.

With rising pulp needs in Europe, and with less and less coniferous pulpwood becoming available for import, the wood-deficit countries have turned their attention to the possibilities offered by the tropical forests in their African dependencies. A notable step forward, was the erection, at Bimbresso on the Ivory Coast, of a 6000-ton pilot plant, intended to demonstrate the possibility of manufacturing on an industrial scale pulp from the mixed hardwoods of the tropical forests. This plant, which started industrial operations in 1952, manufactures kraft paper using a soda-sulphur process; all chemicals are imported. Its start unfortunately coincided with the sharp fall of pulp and paper prices in 1952, and output reached only 1800 tons.

The Ivory Coast project has confirmed that it is technically possible to manufacture pulp and paper from mixed tropical woods. Further experience is necessary to determine the most economic scale of operations in the tropics and to confirm that tropical pulp and paper manufactured therefrom can compete in quality and price on the export market.

Following the Bimbresso experiment, plans are under discussion for the erection at Edea, in the Cameroons, of a 60,000-ton mill. As yet no decision to proceed with this scheme has been taken. French opinion being divided as to the relative merits of pressing on with African developments and additional projects based on straw and temperate hardwoods in metropolitan France. Meanwhile inquiries into the material potentialities at other possible sites, as well as pulping tests, continue.

In the Belgian Congo, preliminary investigations have been conducted into the possibility of developing pulp production in the Mayumbe district. Lukula would seem to be the preferred site, but a good deal of additional information will need to be accumulated before a decision can be taken. A similar investigation has been taking place in the Lake Leopold II region. Here, however, the forests have been inventoried and 150,000 hectares reserved against a contemplated mill capacity of 30,000 tons.

It seems clear that the tropical forests of West and Equatorial Africa are capable of furnishing good quality bleached pulp for printing and writing paper and average quality pulp for kraft papers, and that they will eventually make a significant contribution to the world's pulp and paper supplies. Their potential as a source of newsprint, mechanical and semichemical pulp is not yet established. Every individual project requires the closest scrutiny before a decision can be taken to proceed with construction, partly because of the heterogeneous composition of the forests, partly because of the complex economic factors involved. But many of the obstacles standing in the way of exploiting the tropical forests for pulp will become less serious as time goes on, since local markets will grow in size, communications will improve, and more and cheaper power will become available.

Elsewhere in Africa various schemes are under consideration. Studies have shown that it would be possible to produce 30,000 tons of pulp a year from the papyrus of the Isale-Upemba lakes region of the Belgian Congo; it has not yet been demonstrated, however, whether this material could be economically harvested and transported to the potential site. Recently a small 5000-ton paper and board mill using wattle and waste paper came into operation at Norton, Southern Rhodesia.

The various projects recently completed, under construction or likely to be constructed during the current decade are listed in Table XLVI.

**Table XLVI. Pulp and Paper Projects Under Construction or Likely to Be Constructed During the Coming Decade in Africa**

Thousand metric tons per annum

| Country | Site | Capacity | | | | | Process[a] | Raw material | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Newsprint | Other papers and boards | Mechanical pulp | Chemical pulp | Dissolving pulp | | | |
| Africa | | | | | | | | | |
| South Africa | Tugela | .. | 30 | .. | 30 | .. | 4 | *Pinus sp.* | Kraft pulp and paper |
| | Enstra | .. | 15 | .. | 15 | .. | 4 + 5 | Wood and straw | |
| | Sabie, Eastern Transvaal | 18 | .. | 15 | 3 | .. | 1 + 4 (?) | ..... | ..... |
| | Sabie, Eastern Transvaal | 18 | .. | 15 | 3 | .. | 1 + 4 | *Pinus sp.* | Extension project |
| | Felixton, Zululand | .. | 12 | .. | 10 | .. | (?) | Bagasse | ..... |
| | Umkomaas, Natal | .. | .. | .. | .. | 36 | .. | Eucalyptus | Rayon pulp. Under erection |
| Southern Rhodesia | Norton, Salisbury | .. | 5 | (?) | .. | .. | .. | ..... | ..... |
| Belgian Congo | Kisela-Upamba | .. | .. | .. | 30 | .. | (?) | Papyrus | ..... |
| | Lake Leopold II | .. | .. | .. | 30 | .. | (?) | Tropical woods | ..... |
| French Equatorial Africa | Edea | .. | .. | .. | 60 | .. | .. | Tropical woods | No details available |
| French North Africa | Morocco | .. | .. | .. | 25 | .. | (?) | Esparto grass | No details available |
| | Qued Eilil | .. | .. | .. | (?) | .. | (?) | Esparto grass | No details available |
| | Casablanca | .. | .. | .. | 20 | .. | (?) | Eucalyptus | No details available |
| Egypt | ... | .. | 30 | .. | 25 | .. | .. | Agriculture residues | No details available |
| Total | | 36 | 92 | 30 | 251 | 36 | | | |

[a] (1) Mechanical process; (2) sulphite process; (3) soda process; (4) sulphate process; (5) caustic soda-chlorine process; (6) mechano-chemical process; and (7) semichemical process.

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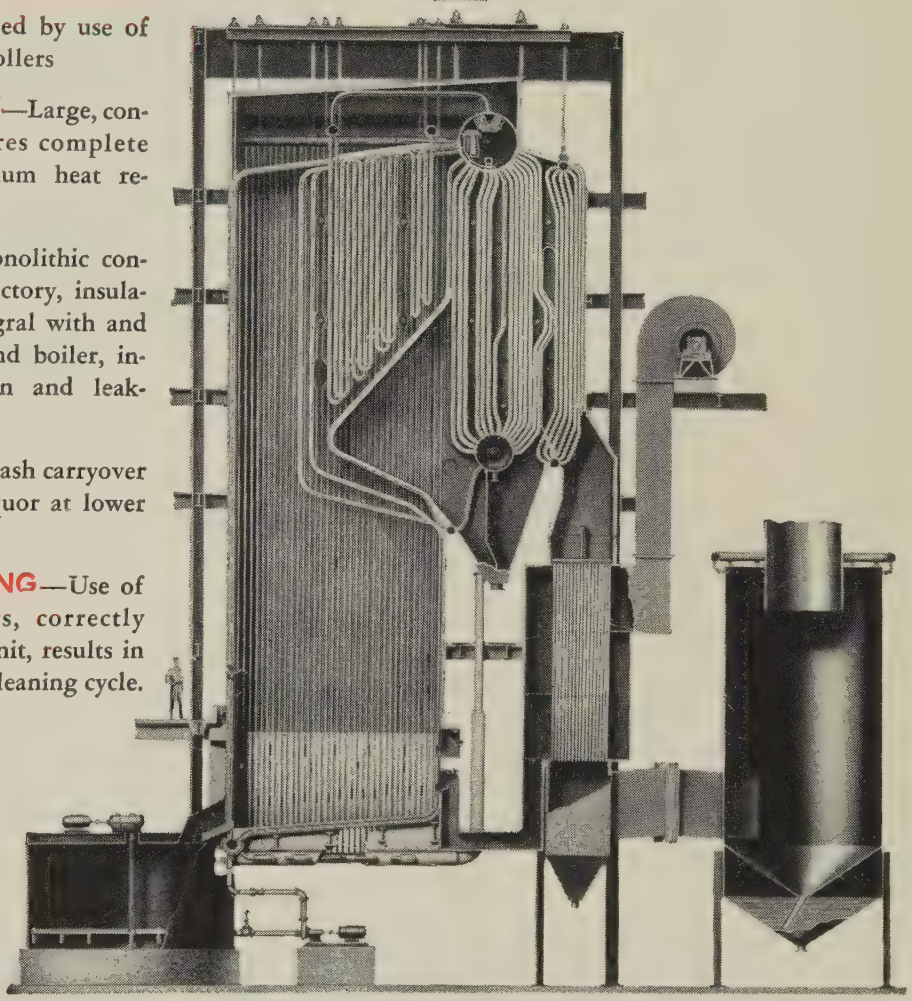

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**Table XLVII. Estimated Increase in Paper and Board Capacity and Demand in Africa, 1950–52 to 1960–62**

Thousand metric tons

| Category | Imports 1950–52 | Production 1950–52 | Estimated increase in capacity to 1960–62 | Estimated increase in demand to 1960–62 | Estimated increase in deficit |
|---|---|---|---|---|---|
| Newsprint | 80 | nil | 36 | 70 | 34 |
| Other paper and board | 280 | 90 | 92 | 190 | 98 |
| Total | 360 | 90 | 128 | 260 | 132 |

Together they would add 130,000 tons of paper and board and more than 300,000 tons of pulp to the region's total capacity. Thus the region's paper and board deficit would grow from 360,000 tons in 1950–52 to nearly 500,000 tons in 1960–62. For newsprint only, the additional imports required would be 30,000 tons; for other categories of paper and board, 100,000 tons. The latter figure, however, would be reduced if certain of the pulp projects planned were built as integrated pulp and paper projects (Table XLVII).

These figures give an indication of the changes that may take place in the balance for the region as a whole. But for the African continent a regional balance can be misleading. The extra capacity contemplated in West and Equatorial Africa, and, though to a lesser extent, that in French North Africa also, goes beyond local requirements and would primarily feed the paper industries of Western Europe. This export surplus would be more than offset by increased import requirements in the rest of the continent. Many territories where consumption is low today, and where imports take the form of finished paper products, will begin to establish paper conversion industries, so that their import needs will shift toward less finished goods. Only in the Union of South Africa does the consumption level today approach European standards. How far it will rise during the current decade will depend as much on South Africa's ability to pay for imports as on the rate of which her scant local resources can be utilized.

Thus the next decade is likely to see important steps taken in the direction of utilizing the immense resources of the African tropical forests for pulp and paper; if successful, they will herald the emergence of a new element of fundamental significance for the world's pulp and paper prospects in the long term. Meanwhile, a variety of influences, paucity of fibrous materials in some areas, economic backwardness in others, will make it necessary for the continent as a whole to import increasing quantities of pulp and paper from other regions during the next 10 years if rapidly rising needs are to be met.

***Oceania***

The 13 million people of Oceania consumed annually on average in 1950–52 675,000 tons of paper and board. Consumption per head, at 52 kg., is second only to that in North America. Newsprint accounts for nearly a third of the paper consumed, and as the following Table XLVIII shows, most of the newsprint and half the consumption of other categories is imported.

In both Australia and New Zealand population is increasing rapidly, immigration adding to the high rate of natural increase; literacy is high, and the rate of industrial expansion since the war has been rapid and is likely to continue. Everything points to a big rise in paper demand in the current decade, and requirements for the region as a whole are estimated to reach 1 million tons by 1960–62, of which 310,000 tons would be newsprint. In terms of pulp, requirements (including dissolving pulp needs) would increase from 630,000 tons in 1950–52 to 950,000 tons. The paper produced within the region was manufactured largely from domestic pulp, imports averaging only 50,000 tons a year of which roughly one third consisted of nonpaper, dissolving pulp.

**Table XLVIII. Production, Imports and Apparent Consumption of Paper and Board in Oceania, 1950–52**

Thousand metric tons

| | Production | Net imports | Apparent consumption |
|---|---|---|---|
| Newsprint | 31 | 185 | 216 |
| Other printing and writing | 30 | 80 | 110 |
| Other paper | 60 | 68 | 128 |
| Board | 166 | 55 | 221 |
| Total | 287 | 388 | 675 |

The forest resources of Australia and New Zealand are, however, very different in quality. Table XLIX, which summarizes the main features, indicates a certain complementarity.

Only a tenth of New Zealand's forests are classed as accessible and in use, as against over a third of Australia. Australia's forests are predominantly broadleaved (mainly eucalyptus); those of New Zealand predominantly coniferous. Standing timber in accessible forests in Australia is estimated at 770 million cu. meters, of which 735 millions are broadleaved; the corresponding figure for New Zealand is 143 million cu. meters, of which only 5 millions are broadleaved. These figures, in conjunction with the percentages accessible quoted in Table XLIX, demonstrate New Zealand's relative wealth of coniferous resources. In 1950–52 Australia, with its much higher population, consumed about six times as much wood pulp as did New Zealand. These facts afford a key to certain developments which are now taking place in the pulp and paper field in this region.

In 1950–52 paper production was mainly concentrated in Australia, and this production was largely based (80%) on eucalyptus pulp, supplemented by imports of long-fibered sulphite pulp. The further developments envisaged are similarly based on eucalyptus, as for example the 45,000 tons newsprint extension at Boyer, completed but awaiting power. In the long term pine plantations by Australian pulp companies will provide a domestic source of long fiber pulp, but for many years yet the industry will require imports, and the

**Table XLIX. Forest Resources in Australia and New Zealand**

| | Percentage of land area forested | Forest area: Total, million hectares | Forest area: Per inhabitant, hectares | Accessible forests as percentage of total forests | Coniferous as percentage of forests in use |
|---|---|---|---|---|---|
| Australia | 5 | 41.4 | 5.1 | 36 | 9 |
| New Zealand | 24 | 6.4 | 3.6 | 11 | 90 |
| Total | 6 | 47.8 | 4.8 | 33 | 13 |

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**Table L. Pulp and Paper Projects Under Construction, or Likely to Be Constructed During the Coming Decade, in Oceania**

Thousand metric tons per annum

| Country | Site | Capacity: Newsprint | Capacity: Other papers and boards | Capacity: Mechanical pulp | Capacity: Chemical pulp | Process[a] | Raw material | Remarks |
|---|---|---|---|---|---|---|---|---|
| Australia | Boyer | 45 | .. | 36 | 10 (?) | 1 + 4 (?) | Eucalyptus | Extension project. Completed, awaiting power |
| | Albury | ... | 10 | .. | ... | ... | Rags and waste paper | ..... |
| | Burnie, Tasmania | ... | 14 | .. | 14 | 3 | Eucalyptus | Glassine papers |
| | Launceston | ... | 10 | .. | ... | 7 | (?) | Boards |
| New Zealand | Kawerau | 75 | .. | 60 | 15 (?) | 1 + 4 (?) | *Pinus radiata* | Previous Warapura project |
| | Kinleith | ... | 25 | .. | 45 | 4 | *Pinus radiata* | ..... |
| Total | | 120 | 59 | 96 | 84 | | | |

[a] (1) Mechanical process; (2) sulphite process; (3) soda process; (4) sulphate process; (5) caustic soda-chlorine process; (6) mechano-chemical process; and (7) semichemical process.

new developments taking place in New Zealand will provide a source close at hand. When the Boyer extension is in full operation Australia's dependence on imported newsprint will be reduced by a third. Today newsprint accounts for half total paper and board imports.

The two major projects under construction in New Zealand are both based on insignis pine plantations. That at Kawerau (originally Marapura) is part of an integrated development scheme, the first unit of which, the sawmill, is expected to start operations next September. By 1956, the newsprint mill of 75,000 tons capacity should be ready. The other project, at Kinleith, scheduled to produce 25,000 tons of paper and 45,000 tons of chemical pulp (partly for export) is already in production and has begun to ship pulp to the Tasmanian newsprint mills. Both these projects have been conceived in terms wider than New Zealand's own immediate needs; together they will help to alleviate Australia's shortage of newsprint and long fiber pulp.

The projects within the region recently completed, under construction or being contemplated are summarized in Table L. They are not, however, in aggregate sufficient to take care of the increase in demand which may reasonably be expected to take place in the current decade.

The region's newsprint deficit would be reduced by 25,000 tons, but that in other paper and board categories would increase by 170,000 tons. The pulp deficit would rise by 150,000 tons.

This does not, however, indicate that a critical situation is likely to arise. First, the projects listed in Table L represent a minimum, rather than a maximum, program; unlike the programs listed in certain other regional chapters, all the projects mentioned are likely to be realized. Second, a number of other expansion schemes are known to be under discussion in Australia, though details of the capacity involved are not available. Interest in these projects declined in the course of 1953 when high stocks of imported paper together with a recession in Australian industry gave rise to certain difficulties in marketing home-produced paper. With the return of more favorable conditions, and a resumption of the rising trend in demand, it is more than likely that several of these expansion projects will advance beyond the discussion stage.

To sum up: everything points to a rapid rise in consumption in Oceania, especially in the packaging categories of paper and board. Developments based on the short-fibered eucalyptus pulp of Australia and the long-fibered insignis pine pulp of New Zealand are likely to reduce the region's dependence on imported newsprint though requirements of other categories of paper and board from other regions may increase.

## THE PROSPECTS FOR FUTURE DEVELOPMENTS IN THE DEFICIT REGIONS

Our review of the situation in the various regions of the world has demonstrated that the possibilities of achieving a substantial increase in pulp and paper output in the traditional producing centers are far from being exhausted. In both Europe and North America, paper and board consumption will continue its upward trend, and requirements at the end of the current decade will be very much higher than they are today. In both regions this trend is well matched by the developments in productive capacity which are taking place; indeed, it is probable that productive capacity in North America is at the present time rising somewhat faster than domestic demand.

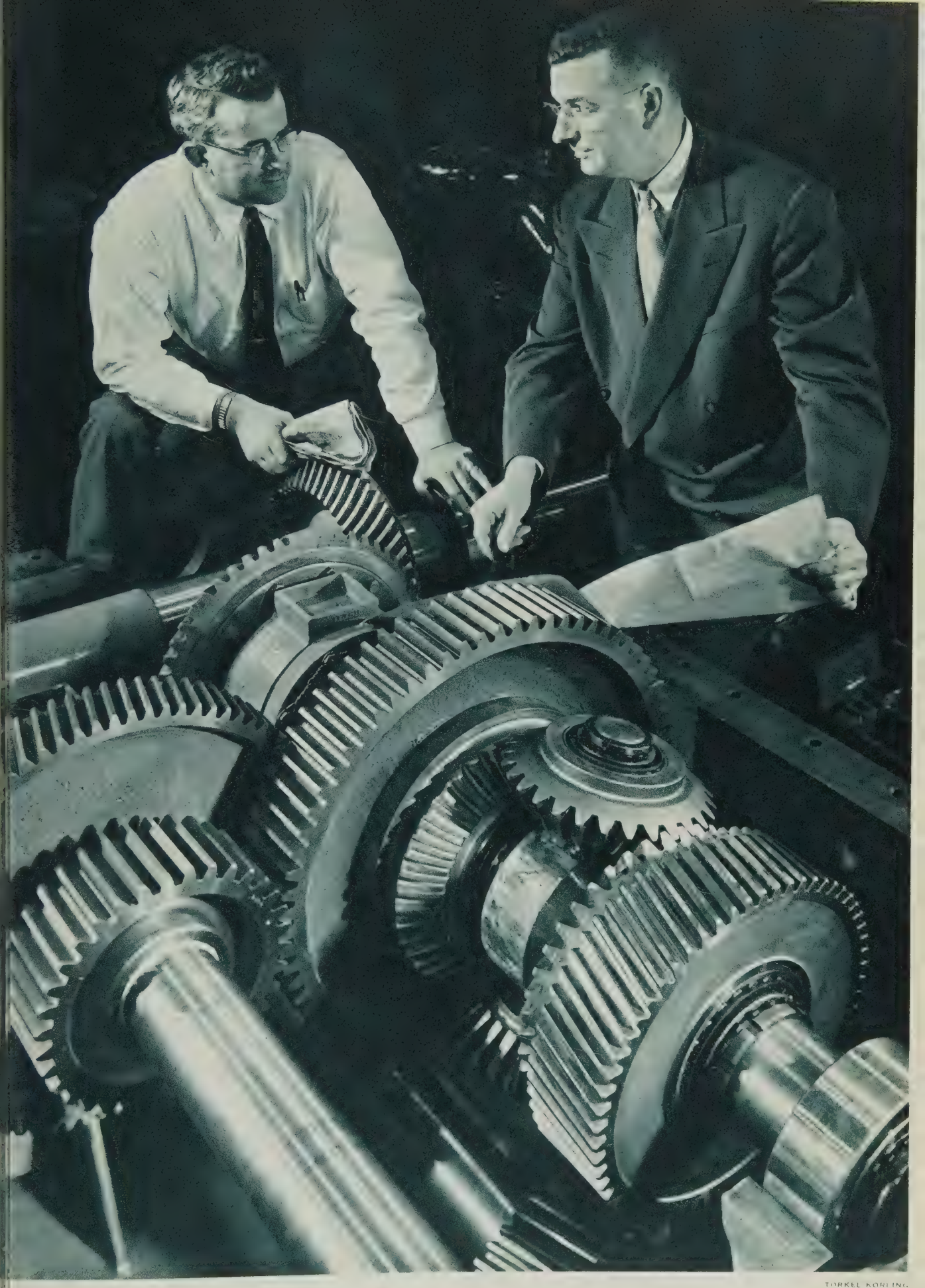
This opens up the possibility of a net contribution from the North American region toward the pulp and paper needs of the less developed areas during the next year or two, supplementing the traditional flow of these commodities from Europe to the rest of the world. For several reasons, however, it would be unwise to assume that this contribution will be a lasting one, or in fact to rely on any substantial increase in the course of the next decade in the surplus available for export to the deficit regions of the world in either of the traditional producing centers. Future investment in both Europe and North America will be guided primarily by the trend in domestic demand in those regions. The future of the overseas export markets is fraught with too many uncertainties to encourage investment in projects which would have to rely principally upon those markets. One of the greatest uncertainties is the ability of deficit countries in the underdeveloped regions to find, and their willingness to devote, resources of foreign exchange to importing additional amounts of pulp and paper.

At the same time, paper and board requirements in all these regions are increasing rapidly with educational and economic advancement, rising welfare and cultural growth. If this

**Table LI. Expected Increases in Capacity and in Requirements in Oceania, 1950–52 to 1960–62**

Thousand metric tons

| Category | Production 1950–52 | Net imports, 1950–52 | Estimated additional capacity by 1960–62 | Estimated increase in requirements by 1960–62 | Estimated increasee in deficit |
|---|---|---|---|---|---|
| Newsprint | 31 | 185 | 120 | 95 | −25 |
| Other paper and board | 256 | 203 | 59 | 230 | 171 |
| Total | 287 | 388 | 179 | 325 | 146 |



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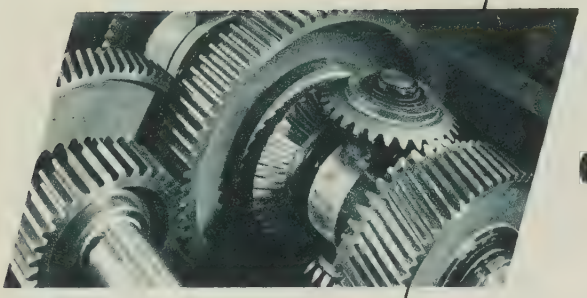

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rising demand is not to be frustrated, there is need therefore of a considerable pulp and paper development based on indigenous resources.

**Table LII. Expected Additions to Pulp and Paper Capacity During the Current Decade in the Deficit Regions of the World**

Thousand metric tons a year

| *Region* | *Newsprint* | *Other paper and board* | *Mechanical* | *Pulp dissolving* | *Other chemical* |
|---|---|---|---|---|---|
| Latin America | 226 | 326 | 184 | 50 | 448 |
| Far East (excl. China and Japan) | 60 | 332 | 42 | — | 355 |
| Near and Middle East | 3 | 65 | — | — | 44 |
| Africa | 36 | 92 | 30 | 36 | 251 |
| Oceania | 120 | 59 | 96 | — | 84 |
| Total | 445 | 874 | 352 | 86 | 1182 |

Most countries are conscious of this need, and in every part of the world new mills are being built, plans are being discussed, and resources surveyed. Table LII summarizes the developments which are taking place and the projects which are likely to be realized during the present decade.

It must not be overlooked that the figures contained in this table (which summarizes the more detailed tables which have been presented in the regional reviews in the previous chapter) are highly provisional. Many difficulties confront any attempt to gage the extent to which additional capacity is likely to be forthcoming during the next 10 years or so. A new pulp or paper mill represents a considerable investment which might, for example, reach $20 million in the case of an integrated newsprint mill of 50,000 tons capacity. Several years may elapse between the time when a new mill enters on the planning stage and the time when production begins. On a rising market both the planning and construction stages are likely to be accelerated; when the market outlook is uncertain planning proceeds more slowly and construction may be slowed down or postponed. In but few countries does firm and systematic information concerning new investment exist, and the numerous projects reported may range in certainty from a firm intention to build, with contracts already placed, to what is little more than a gleam in the eye of an investor. The above table summarizes all the information collected concerning present plans in the less developed regions, as well as all those projects which have been examined by or suggested by the FAO Survey Missions and which appear to offer a real hope of realization within the next decade.

This list is not exhaustive. For a number of countries information is lacking and there are other countries which might offer possibilities which have not been visited by FAO Survey Missions. It is believed, however, that few countries which possess indigenous resources and in which the local demand for paper is likely to reach a significant level during the decade have been omitted. Thus, though some new projects may arise, the likelihood is that the above table overstates the probable developments in the next decade, since not all the plans which have been listed will be realized. The necessary investment may not be forthcoming; some projects, on more detailed examination, may be rejected; and in certain cases it may prove necessary to make a choice between alternative projects.

It is possible to divide the various projects, in a rough and ready way, into two groups. Group A includes all those projects which are already under construction and all others whose execution on the basis of information so far accumulated may be regarded as certain or highly probable within the decade. Group B includes all other projects which have been listed; all these, on the basis of the preliminary investigations conducted, show distinct promise; in each case, however, certain elements of information necessary before a firm decision to build is taken are lacking, e.g., on the suitability or extent of the raw material resources, on the availability of power or water, on marketing possibilities, etc. Figures corresponding to this rough distinction are given in Table LIII.

Though the figures of new developments given in this and the preceding chapter must therefore be treated with reserve, both in detail and in aggregate, they are nevertheless useful since they provide an indication of what is likely to happen in the coming years. It may be assumed that actual achievement will lie somewhere between the aggregates set out in the first and third lines of Table LIII. That is to say, present plans envisage the creation of between 900,000 and 1,300,000 tons of additional paper capacity (including 280,000 to 440,000 tons of newsprint) and of 1,250,000 to 1.6 million tons of new pulping capacity in the course of the decade. By any standards, these are impressive totals; at the maximum they would imply a doubling of paper production and a threefold to fourfold increase in pulp production* in the course of a decade. Viewed against the background of potential future needs, however, these totals are less imposing. For if we assume that all the projects which have been included in the foregoing tables are carried into execution, and if we further assume that future demand comes up to the levels estimated, then it becomes clear that the gap between these regions' own production and their requirements will widen (Table LIV).

Additional newsprint capacity amounts to about 70% of the estimated increase in requirements; for other categories of paper and board new capacity is rather more than half of the increase in demand estimated.

These figures exclude Japan and China, thus implicitly assuming that these two countries will be in a position to cover the rise in their own domestic demand. Though this will probably be true for Japan, it may not be true for China. And in fact China's import needs are likely to increase more rapidly than Japan's export potential in the immediate future.

If these figures are taken at their face value, they mean that at the end of the current decade the regions enumerated will *either* need to import nearly 900,000 tons of paper and board more than they do today (including 150,000 tons more newsprint), *or* they will have to be content with a slower rise in paper consumption levels than would correspond to their general economic and cultural development, *or* they will need

* I.e., in the world excluding North America, Europe, USSR., China, and Japan.

The figures in the last column of the table, "increase in deficit", slightly overstate the increase in capacity that would be necessary to limit dependence on imports to the 1950–52 rate because of the existence of capacity today unused in certain regions. The difference is only important in Latin America, where it is estimated that 485,000 tons of additional capacity would be required as against the 538,000 tons "increase in deficit" indicated in Table LIV.

**Table LIII. Estimated Additions to Capacity in the Less-Developed Regions During the Current Decade**

Thousand metric tons a year

| | *Newsprint* | *Other paper and board* | *All paper and board* | *Mechanical pulp* | *Dissolving pulp* | *Other chemical pulp* | *All pulp* |
|---|---|---|---|---|---|---|---|
| Group A projects | 283 | 636 | 919 | 292 | 77 | 885 | 1254 |
| Group B projects | 162 | 238 | 400 | 60 | 9 | 297 | 366 |
| Total | 445 | 874 | 1319 | 352 | 86 | 1182 | 1620 |

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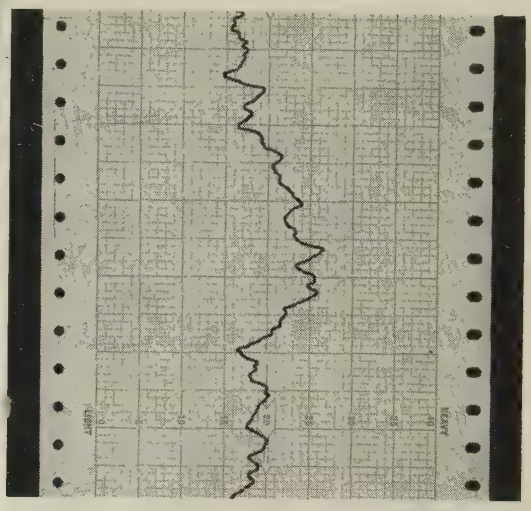

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to develop their indigenous resources at a rate considerably faster than that indicated by present plans.

It has perhaps been sufficiently emphasized that it would be unwise to take the figures at their face value. There can be no precision either in estimating the exact trend of demand or in appraising investment plans. The sizes of the gaps indicated in Table LIV should not, therefore, be a matter for emphasis. But the general conclusion they point to—that there is a disparity between the rate at which demand is rising and the ability to satisfy that demand—seems inescapable. After making full allowance for the difficulties attached to any prognosis of this kind, it seems clear that the developments at present contemplated will not be sufficient to diminish the gap between domestic needs and the extent to which those needs can be satisfied from domestic resources.

**Table LIV. Comparison Between Estimated Increase in Paper Requirements and Estimated Increase in Paper Capacity, 1950–52 to 1960–62**

Thousand metric tons a year

| *Region* | *Imports 1950–52* | *Regional production 1950–52* | *Estimated additional capacity by 1960–62* | *Estimated increase in demand by 1960–62* | *Increase in deficit as compared with 1950–52* |
|---|---|---|---|---|---|
| Latin America | 640 | 810 | 552 | 1090 | 538 |
| Far East (excluding China and Japan) | 375 | 190 | 392 | 465 | 73 |
| Near and Middle East | 74 | 27 | 68 | 49 | −19 |
| Africa | 360 | 90 | 128 | 260 | 132 |
| Oceania | 388 | 287 | 179 | 325 | 146 |
| Total | 1837 | 1404 | 1319 | 2189 | 870 |
| Of which: | | | | | |
| Newsprint | 783 | 111 | 445 | 630 | 185 |
| Other paper and board | 1054 | 1293 | 874 | 1559 | 685 |

We have seen that it would be idle to expect any startling increase in imports from the traditional producing centers. Therefore, if standards of paper consumption are to rise in harmony with economic growth and rising welfare, a rate of development of capacity in these regions higher than at present envisaged will be required.

What are the possibilities of achieving an accelerated development in these regions?

The more important potentials of particular regions have been referred to previously where the situation in each region is summarized. In the light of these discussions it can be stated unequivocally that the world's store of fibrous material does not today and will not in the future set a *technical* limit to the expansion of the pulp and paper industry. In the first place there are vast resources today inaccessible which could be made accessible if the need arose. Secondly, of the accessible resources, only a fraction today are utilized for pulping. Thirdly, proper management of existing accessible resources can ensure continuing and even increased yield in perpetuity.

The limits to the expansion of world pulp and paper production at any given time are economic rather than technical, though they are partly conditioned by the contemporary fund of technical knowledge. Furthermore, the actual location of production depends not only on access to suitable raw materials; it is governed, as has already been stressed, by the degree of general industrial development and by proximity to markets. These factors decisively affect the cost of paper delivered to the consumer and thus determine the regional distribution of the pulp and paper industry.

This is why world production of pulp and paper is today concentrated in Europe and North America, both highly developed regions with vast markets close at hand and enjoying access to large areas of coniferous woods offering an excellent raw material for pulp and paper. Hence these regions have come to supply a considerable proportion of the pulp and paper requirements of less developed regions, in spite of the fact that countries in these latter regions, with one or two notable exceptions, have themselves vast resources of fibrous materials. Herein lies the explanation of the fact, that on the one hand, Chilean conifers, Burmese bamboo, Amazon and West African hardwoods are as yet hardly tapped for pulping, while, on the other hand, the Union of South Africa, one of the most ill-endowed areas of Africa from the raw materials point of view, accounts for over half the continent's production.

Europe and North America's pre-eminence in pulp and paper production is associated with the possession of immense coniferous reserves; it is not, in the last analysis, based on the possession of those reserves. It was the general pattern of world economic development which determined that those reserves should be the first to be exploited.

If by the waving of some magic wand the vegetative pattern of the earth's surface were to be transformed overnight, so that Canada and the Scandinavian peninsula became covered with dense tropical forest and bamboo while forests of spruce, fir and pine extended in an immense belt across Central and South America, Africa and the Far East, can it be imagined that the present world distribution of the pulp and paper industry would be speedily reversed? On the contrary ,it is highly probable that the present pattern would be hardly modified, if at all. The technical knowledge accumulated skills and inventiveness of the traditional producing centers, driven by market compulsions, would within a short space of time solve the problems attached to the exploitation of new materials.

Today, new economic compulsions are making themselves felt in those regions of the world deficit in pulp and paper. These regions have themselves abundant fibrous resources. These resources include conifers, but for the most part they differ in character from those in Europe and North America, consisting mainly of tropical hardwoods, bamboo, bagasse, and straw. With the development of suitable pulping methods for these raw materials the production of pulp and paper in the less-developed regions has progressed and will continue to do so, along with the growth of markets and general industrial development. It is abundantly clear that there are today few technical obstacles standing in the way of utilizing these new resources. Moreover the fund of technical knowledge available is being added to daily, at a rate perhaps unprecedented in the hundred years' history of modern pulp and papermaking.

At the same time the economic and environmental factors which determine the possibilities of successful investment in pulp and paper projects become steadily more propitious. Local markets are increasing in size and diversity; communications are improving; local fuel and power resources are being developed.

Thus in every way the stage is set for a more rapid expansion in pulp and paper capacity in the less-developed regions of the world than has hitherto been witnessed. And the present trend toward a measure of decentralization of the world's pulp and paper production is as desirable as it is inevitable.

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It represents, in fact, one facet of a world-wide process of adjustment to the social, political, and economic changes today taking place. It is in the interest of consumers in these regions, and of producers everywhere, that this adjustment should proceed soundly and even warily. Already there have been instances where governments, and investors, conscious of the trends now delineated in this survey, have lent their authority and backing to projects whose viability in the long term is by no means assured. There is a danger that misinvestment may take place; and ill-judged ventures are apt to have undesirable repercussions which go far beyond the particular project concerned, frequently discouraging other and healthier developments.

The decision to proceed with the construction of a pulp or paper mill in a less-developed area of the world is not one that can be lightly taken.

The existence of an adequate supply of fibrous material suitable for pulping and of the technical possibilities of doing so does not by any means imply that conditions are suitable for the establishment of a pulp and paper industry. Very many other conditions need to be satisfied, such as the need for chemicals, fuel power, water, labor, and capital. There are, however, a number of other economic considerations which need to be taken into account when the establishment of a new pulp or paper industry is contemplated and which have so far been mentioned only in passing, if at all.

Some of these relate to the nature of the commodity itself. In this survey, future requirements have been aggregated in terms of tons of wood pulp. But pulp is by no means a homogeneous commodity; according to the fiber from which it is made, and the processing it undergoes, it may differ considerably in any one of many characteristics which alter its suitability for the manufacture of any one of a great many types of paper and board. The buyer of market pulp requires that the commodity he purchases shall conform closely to certain specifications, determined by the nature of the plant he possesses and the particular types of paper he produces. In some cases, he can lower his quality requirements, but only if he is prepared to accept a lower quality in (and hence lower price for) his own finished product. For some paper products it is not possible to lower the pulp specifications at all; hence certain pulps falling below a minimum standard quality may be completely unmarketable. Thus, while the buyer of pulp will in many cases be prepared to pay a premium for high quality, it does not, in general, follow that he will be prepared to accept a very inferior quality, however cheap.

Because the capital cost of a papermaking plant is high, interruptions in the supply of materials can be disastrous. The pulp buyer is therefore interested also in the continuity and security of his supplies. For this, too, he is therefore prepared to pay a premium, either directly in cash, or indirectly by accepting a slightly lower quality if his supplies are more certain. And for this reason he will prefer, other things being equal, to obtain his supplies from a source close at hand rather than from a distant source where arrivals may be subject to transport hazards. The possibility of fluctuations in freight costs, exchange rates, export and import regulations and restrictions will all influence him in the same direction. To simplify the pricing and marketing of his own products, he will prefer not to obtain his supplies from a source subject to sudden price changes.

The pulp user's interest in ensuring a secure and continuous supply of pulp of the right quality, free from sudden price fluctuations, may lead to him seeking to own or control the source of his pulp supply. This is one of the factors making for increased integration. Another important factor making for integration, in the geographical as well as the financial sense, is the reduction in costs which result from the manufacture of pulp and paper in a combined operation. A single power installation can serve both stages of manufacture; savings arise from the fact that it is no longer necessary to dry, handle, and transport the pulp; moreover in some cases the drying of slush pulp leads to a loss in quality, especially in mechanical strength. The economies of integration are most marked in the production of newsprint and most wrapping papers and board where large quantities are made to uniform specifications from only one or two kinds of pulp. They are less marked in the production of finer papers, which are usually made in smaller quantities, often in great variety to meet customers' special requirements, and using many different types and grades of pulp. In the latter case, therefore, market considerations such as the need to effect prompt delivery of special qualities in small quantities, may offset the advantages of integration.

In selecting the site for a nonintegrated pulp factory from a variety of sites which satisfy certain basic conditions, the relative pulls of the various locational factors have to be weighed and the ideal compromise decided upon. The main factors are those of the fibrous material, chemicals, fuel and power, water, and the market. A different web of factors influences the choice of site for a paper factory; in particular marketing considerations usually weigh more heavily. Choosing the ideal site for an integrated pulp and paper plant is thus an even more complex problem.

The problem is further complicated by the fact that the cost curves for pulp manufacture and papermaking are by no means the same. For both the cost of production per unit of output diminishes rapidly with an increase in the scale of operations at first; it then flattens out and the probability is (though data on this point are lacking) that ultimately a stage will be reached when unit costs begin to rise again. This is likely to be true more particularly for pulp establishments, since pulpwood costs will tend to rise as the more accessible supplies become depleted. But though the curve will have the same general shape in both cases, the minimum economic size for a paper mill will, in general, be considerably smaller than that for a pulp mill. Needless, to say, it differs for different types of pulp and for different categories of paper and board; it is smaller, for example, for a factory doing a custom trade in many varieties of fine papers, involving frequent changeovers, than for a newsprint or kraft paper mill. Nor can it be said that for any given type of mill there is a determinable, universally applicable, economic size governed by technical considerations, since technical considerations alone are not decisive.

Paper is even less a homogeneous commodity than is pulp. And what has been said above relating to the pulp consumer's interest in security and continuity of supply, quality specifications, freedom from price fluctuations, etc., applies equally to the paper converter, be he newspaper publisher, cardboard box maker, or manufacturing stationer. A demand for, say, 30,000 tons of paper and board in a given country does not imply the existence of a market warranting the establishment of a paper mill, even though this figure may considerably exceed the minimum economic size of such a mill. For in fact there is not one but several different markets, each capable of being satisfied only by particular categories of paper and board; and different categories must, generally speaking, be made on different types of machine. It is true that various multipurpose machines do, in fact, exist, but this fact only modifies—it does not vitiate—the general statement just made. Other things being equal, papers produced on a multipurpose machine will be more costly than papers produced on single purpose machines if the latter are of economic size and can be continuously employed. But if the market is small, a multipurpose machine can be operated more economically. Large integrated pulp and paper concerns in the traditional producing centers rely mainly on "one purpose" machines.

The considerations which have been set out in very general terms in the foregoing paragraphs are no more than elementary truths, familiar to most readers. Nevertheless, they have important implications when we come to consider the

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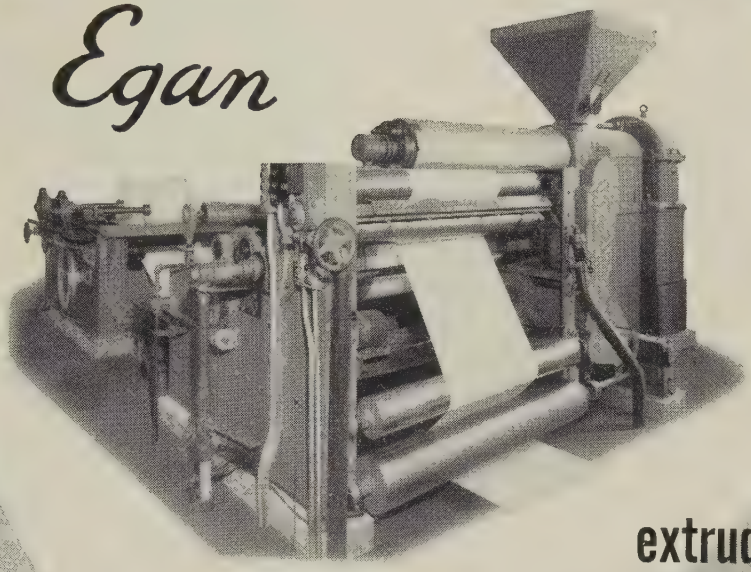

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establishment of a new industry in a hitherto underdeveloped country, and experience shows that certain of these implications are sometimes overlooked.

A new pulp and paper industry must look primarily to the domestic market. In specially favorable circumstances it may be able to rely on a supplementary market in neighboring countries. It should certainly not have to depend, in order to operate economically, on sales on the free international market. First, because the international market is small in relation to total world production and consumption, especially for pulp. Second, the nature of the commodity has given rise to close producer-consumer ties which dominate a large area of the apparent free market. Third, cost estimates for new plants outside the traditional producing centers are apt to be precarious, especially if they are to operate on non-traditional fibers. And finally, it is not always easy to say with certainty in advance that the qualities produced will be competitive.

This is not to say that there is no possibility that pulp and paper establishments in new areas will ever find international markets. As new industries develop, experience of actual operations will show whether their products are capable of competing in price and quality on the international market. If the indications are favorable, investment will be forthcoming to expand capacity beyond the level determined by local requirements. The essential point is that new industries must feel their way gradually into international markets; they cannot in advance bank on success. Nor can it be carelessly assumed that a new project will necessarily be able to compete successfully in neighboring markets, for it must not be forgotten that geography can be misleading. Unless road and rail facilities are adequate, and fuel, labor, and maintenance cheap, a land haul of several hundred miles may be more expensive than a sea haul of several thousand miles.

The element of uncertainty about costs under actual operating conditions is by no means as strong a deterrent in planning a mill to satisfy local demand only, especially in areas remote from the main exporting countries. Assured of continuous supplies close at hand, the market will often be willing to forego some price and quality advantage. Needless to say, this does not justify high cost ventures which are likely to lead to prices quite out of line with world prices. It does mean, however, that a new project should not necessarily be condemned out of hand simply because it does not satisfy entirely the stringent conditions that would be laid down in considering the establishment of a project in a high competitive producing center.

Before any decision is taken to build a new mill, it is imperative that the character and extent of the existing and potential local market be carefully analyzed in detail. The market is not necessarily limited to the domestic consumption of raw paper and board; the bringing into existence of a local supply may automatically extend the market by favoring the local establishment of converting industries capable of replacing converted paper products hitherto imported. The analysis of the market will show what kinds of paper and board are in demand, and what opportunity is offered of economically operating different kinds and sizes of machines.

Because markets in many underdeveloped countries are small but rapidly expanding it may be possible to make out a case in some instances for a small paper or board factory operating on waste paper, sundry locally available fibers and imported pulp. Such projects should from the outset be planned so as to afford the possibility of expansion as the market grows, and with the ultimate desirability of developing local sources of pulp supply ever in mind.

A discussion of production factors would indicate how very different conditions of pulp and paper production in the less developed regions may be from those existing in North America and Western Europe. The lessons and conclusions which may be drawn from operations in the latter regions may have a very limited application in, say, Latin America or the Far East. Over large areas of the world the commercial conditions which today prevail in the pulp and paper field approximate those which existed in Europe half-a-century ago. There is great scope for initiative and improvisation; there is need for flexibility in approach, ability to adapt plans to rapidly changing circumstances. In general, enterprises whose initial scale of operations is small by Western standards may often be the soundest economic propositions.

This very brief and inevitably superficial discussion of some of the economic considerations relevant to the establishment of new pulp and paper industries in less-developed areas leads to the following conclusions.

The detailed investigation which should precede any decision to create new pulp and paper capacity must cover not only the raw material resources and the physical factors of production, but also the less obvious circumstances influencing production costs and the concrete possibilities of marketing the products.

Only in rare and exceptional cases will it be wise to initiate a project which from the outset would have to depend on outlets other than the domestic market for its economic operation.

A project in a hitherto underdeveloped region whose intended scale of operations falls below that judged economic in North America or Western Europe is not necessarily unsound.

In siting a new project, it is desirable to pay attention to future needs and the possibility of future expansion.

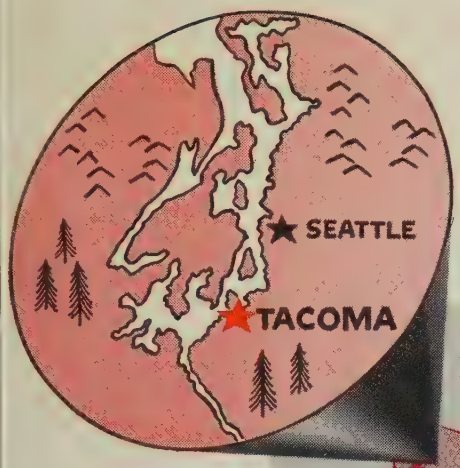
The perspective for the development of pulp and paper production in the underdeveloped regions is determined by certain undeniable trends. Paper and board requirements are rising rapidly and will continue to rise. The possibility of satisfying these requirements by increasing imports from the traditional exporting centers will be limited by the ability to pay for imports on an increasing scale. In the long term, as consumption standards begin to approach contemporary European standards, a further limit will make itself felt—the physical inability of European and North American resources to satisfy their own regional needs and at the same time satisfy an ever-increasing extra-regional demand. It is therefore inevitable that the other regions of the world will progressively develop their own resources.

In the initial stages, development will inevitably be scattered; in some cases it will be experimental; frequently it will be on a small scale. With the steady accumulation of experience of actual operating conditions, certain of the new centers will prove themselves more fitted than others for further expansion. Within each region specialization and local concentrations of the industry will develop. Ultimately particular countries or areas will prove themselves capable of fulfilling, within their regions, the role that Scandinavia plays in Europe today.

It is in the interest of governments, investors, and peoples alike that this progress should be an orderly one; that careful appraisal of each individual project insures the viability of all those which are actually initiated, reducing false starts to a minimum. Only thus will it be possible to avoid the creation of uneconomic enterprises which, by leading to restrictions on trade, inhibit the rise in paper consumption appropriate to rising educational, cultural and material standards.

## CONCLUSIONS

This survey confirms the general belief that the trend of demand for pulp and paper will continue upward in the coming years. Though in absolute terms the increases will continue to be greatest in the main pulp-consuming centers today—Europe and North America—it is in the less developed regions that the rate of increase is likely to be most rapid. In spite of this, great disparities between per capita consumption in the different regions of the world will remain.

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Pulp and paper production in Europe and North America will continue to grow, and technical advances will prevent any lack of material resources from inhibiting that expansion. New investment is likely to be principally guided by the trend in domestic demand in those regions. It seems unlikely, for several reasons, that the margin available for export to other regions will rise substantially in the long term. Moreover, attention has been drawn in this survey to the preponderating share of North America in both the world's consumption and production of pulp and paper. Should North American demand develop unevenly and temporarily outrun domestic supply, as has happened in the past, the demand would spill over into the international market and less fortunate countries would again face pulp and paper shortages. Conversely, should the rise in North American demand lag and fall short of productive capacity, large producers will be happy to avail themselves of the alternative outlets afforded by markets in the deficit regions. The current pace of capacity expansion suggests that the latter case could arise in the immediate future.

But though the surplus available for export in the old production centers will fluctuate, conceivably rising above present levels from time to time, clearly two thirds of humanity cannot be content to have their supplies of an essential commodity interrupted by periodical fluctuations. And in any case a long term increase in the exportable surplus commensurate with the rising needs of the deficit regions does not seem likely.

It is probable, therefore, that other regions, hitherto wholly or mainly dependent on imports, will be unable to satisfy their rising requirements in the long term unless in the coming years more additional capacity is created within those regions than is at present contemplated. The additional capacity required to meet future needs by 1960–62 according to present forecasts may be estimated** at close on a million tons; even if this could be achieved, there would remain a need for imports at the present level.

Moreover, past trends of consumption in the less developed regions of the world suggest that, so long as these countries depend on imports for most of their supplies, standards of consumption will remain below the levels appropriate to the stage of economic and cultural development they have attained. Thus, an expansion in local supply does not automatically bring a corresponding curtailment in import needs; its main effect is to enable latent demand to become effective. Though we customarily think of demand as evoking supply, it must not be overlooked that supply has a demand-creating effect. Hence, the exporting countries which have traditionally satisfied a large part of the needs of the less developed regions need not fear that each and every advance in indigenous production in those regions will lead to a sharp corresponding contraction in import requirements, though the pattern of those requirements may change. In any case it is clear that indigenous production is not likely to expand sufficiently rapidly to keep pace with rising domestic demand.

If, therefore, those regions where per capita consumption is admittedly too low today are to be assured of a supply of newsprint, printing paper and other papers adequate to meet their essential educational, cultural, and industrial needs, it will be necessary to take special measures to develop pulp and paper capacity in regions outside the present main pulp-producing areas at a rate more rapidly than is at present envisaged. This implies a measure of decentralization of the world's pulp and paper capacity. Such a development would represent not only a contribution to the solution of the world's pulp and paper problem; it would accord with the declared aims of the United Nations to facilitate the economic advance of the underdeveloped countries.

Do the conditions for such a development exist? This survey shows clearly that, so far as resources are concerned, they do. Moreover, there exists today a fund of knowledge of processes and techniques, a fund likely to be added to in the coming years, which will permit the exploitation of these resources. Projects already being built or under construction, together with other projects suggested which seem capable of early realization, would make a substantial contribution toward meeting the deficits which could be expected 10 years hence. Further technical developments, and the further exploitation of existing resources, could in the long term insure that all potential future paper needs are safeguarded.

In aggregate, the projects listed previously may seem inadequate in relation to potential future requirements in the regions concerned. Yet such a program must be reckoned ambitious in relation to the present economic possibilities in those regions. For it must be stressed once again that the pulp and paper problem in the less developed regions is as much an economic and financial problem as a technical one. Though optimism about the long term possibilities is justifiable, a grandiose initial program would be unrealistic in the light of the conditions obtaining today.

For it has to be remembered that a new pulp and paper project should not be established in an underdeveloped country in isolation. Ideally, it should figure as one project among several, in a coordinated development plan—a plan which embraces, besides industrial developments, the establishment of road and rail communications, power resources, housing, and amenities. Lopsided development can thus be guarded against, and overheads which should be spread over a total plan prevented from becoming an insupportable charge on an isolated project. Where this is not possible, as may often be the case in the exploitation of tropical forests, it would be advisable to think in terms of an integrated timber industry, including sawmills, plywood factory, etc., in order to permit the full utilization of the heterogeneous raw material offered by these forests and, incidentally, to facilitate the silvicultural measures necessary to ensure a sustained yield.

Furthermore, the amount of capital required to realize only the projects listed in the previous chapter would be very great, in the order of $650 million. Another $400 million would be required to establish industries that would fully meet the increase in demand. Though some private foreign capital may be attracted, and some assistance may be expected from international lending institutions, a considerable part will still have to be found from domestic sources in competition with projects in other fields. Thus, the availability of capital will set a limit to what can be achieved in the immediate future.

It must not be overlooked that proposals for the development of new pulp and paper capacity in the less developed regions of the world—Latin America, Africa, Asia, and the Far East—and in Oceania, multiplied rapidly during the period of soaring prices 1949–51.

It is not difficult to see why pulp and paper investment appeared attractive in the boom years. The desire on the part of less-fortunate countries to find a means of ensuring continuity of supplies, of sheltering themselves from fluctuations in the world market and of conserving foreign exchange, was and remains a natural and legitimate aspiration.

Accepting the thesis that a measure of decentralization is desirable, the temptation may arise to give unqualified support to any project which expresses this tendency. The need therefore arises for a critical assessment of existing and potential projects, from the point of view of continuity of materials supply, suitability of materials, labor supply, power, chemicals, water supply, communications, etc., and with special reference to estimated production costs and estimate effective demand, domestic and regional. This assessment should be made, not against the background of the exceptional boom years of 1949–51—when scarcity and soaring prices

** Excluding additional capacity required in China and Japan.

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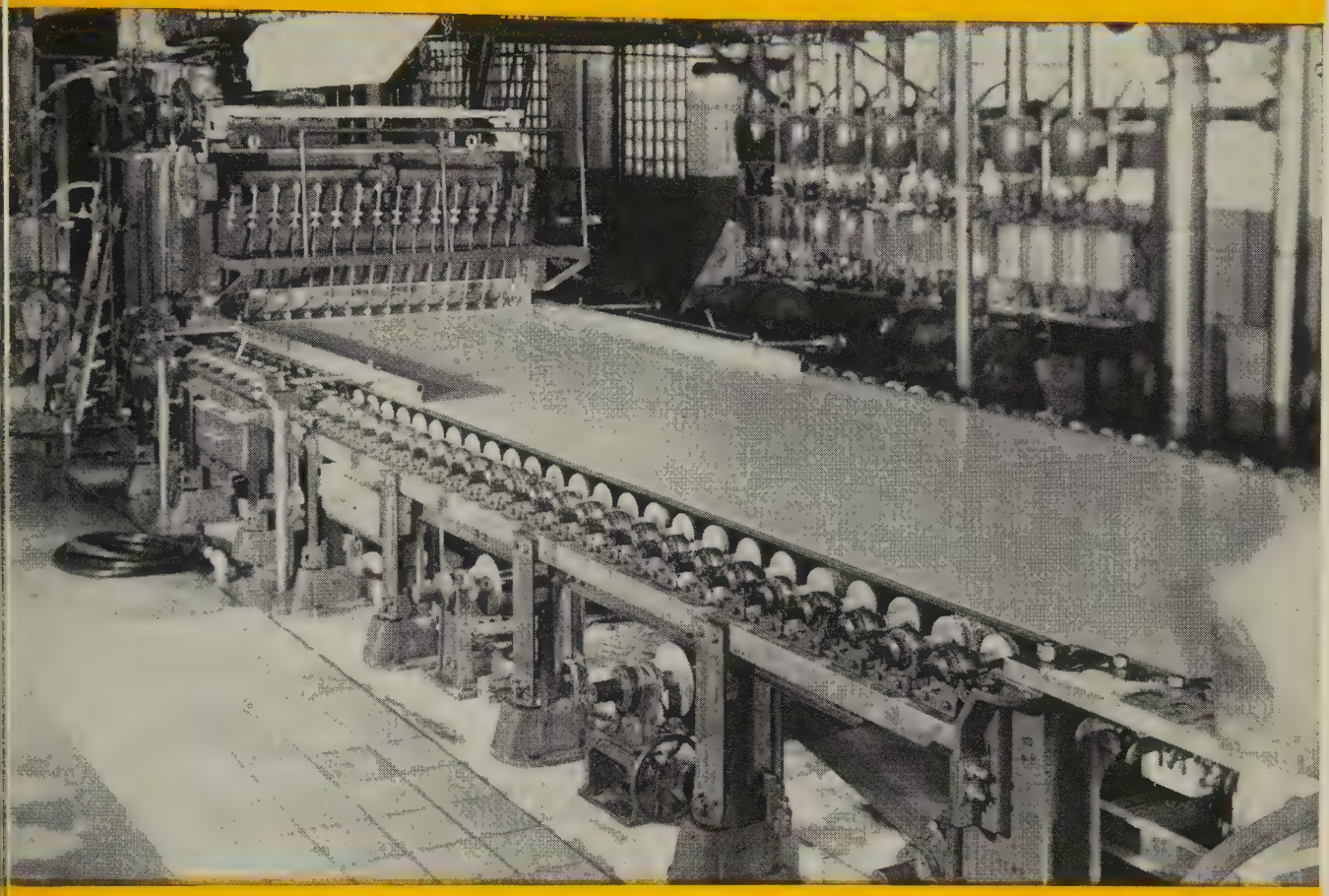

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made any prospect of diminishing national dependence on the international market desirable; nor against the more somber tone of the world market in 1952, when collapsing prices, buyers' caution, and idle mills in traditional export centers seemed to deny earlier fears of impending crisis. A just appraisal must be related to the best estimates available of the likely trend of demand over a period of years, and the probabilities that existing sources of supply will be equal to meeting that demand.

The general picture which this survey affords of world pulp and paper prospects is not one of existing or impending crisis; the situation revealed is not one that calls for precipitate and far-reaching action. The steady process of adjustment necessary to meet present trends in world consumption is already taking place. There is reason to believe, however, that it is not taking place sufficiently rapidly. To some extent this may be ascribed to the inhibiting effects of the recession which followed the 1950–51 boom. A failure to accelerate this process of adjustment could have two consequences. The first, which would arise if a sudden access of demand in the main consuming centers were to bring a repetition of the recent cycle, would confront deficit countries with the same difficulties in securing essential supplies as they experienced in 1951. The second, none the less serious because it would be manifest in a less spectacular way, would be a cumulative lag in paper consumption standards in the deficit countries behind the levels they might otherwise be expected to attain. In the former case, the cries of paper-starved countries would again be heard; the world conscience would be stirred; there would be pressure for emergency action at the international level; and in many places the advocates of national self-sufficiency in paper would gain ground. In the latter case, the effects may pass almost unnoticed; somewhat fewer books will be printed and fewer newspapers read than might have been; schools will economize more in their use of stationery; packaging standards will not achieve quite the same hygienic level. There would be no crisis; but there would be a steady, if hardly perceptible, brake on progress.

### *Role of International Agencies*

Have the international agencies any part to play in accelerating this process of adjustment? Undoubtedly they have. Within its own particular sphere each agency can make a positive contribution. For the most part this contribution will consist in facilitating the interchange of information, stimulating the collection and promoting the diffusion of the data which afford the basis for governmental and investors' decisions. It would be idle to expect spectacular results in the immediate future, or to entertain exaggerated hopes of the part which the international agencies can play. Essentially their role must be that of honest brokers. They can assemble, analyze, and make freely available the relevant facts; they can give impartial technical advice at all stages. When it comes to the implementation of specific plans, the problem has passed beyond their scope. The way in which particular projects are realized will vary from country to country, depending on the particular economic and political structure of the country concerned. In all cases, considerable capital will be needed and the natural source of this capital will normally be the private investor in the country concerned, though it may be expected that this will in many cases be joined by capital from countries with long experience of pulp and paper production.

To UNESCO belongs the credit of first alerting public opinion to the dangers which inadequate supplies of newsprint and other printing and writing paper entailed for educational, scientific, and cultural progress. By collecting systematic statistics and information on newsprint, production, trade, consumption, and price levels, and on the many factors affecting consumption trends, and by providing for forecasts of future needs, UNESCO will continue to add precision and clarity to the demand frame which will condition future developments on the side of supply.

Already the International Bank has made a notable contribution to securing the world's future needs of paper by loans for pulp and paper projects in several countries. Occasions may arise in the future where it can extend similar assistance, and the investment funds of other international lending institutions may also be able to supplement the flow of private capital. The International Bank's most important function, however, will be to give objective and expert advice to governments on the economic aspects of proposed pulp and paper projects, and on the part which pulp and paper investment should play in total investment patterns. Here economic experts of the Technical Assistance Administration will also be able to help.

Several of the Regional Economic Commissions have long been interested in pulp and paper problems. This will continue, and the possibilities of interregional collaboration may multiply. The special problems of Latin America have received considerable attention in recent years: FAO survey teams have visited 12 Latin-American countries and the Economic Commission for Latin America, in collaboration with FAO, has published a "Preliminary Study of the Possibilities for the Development of the Pulp and Paper Industry in Latin America." The studies which have been carried out and the information which has been assembled have led to the convening of a conference at Buenos Aires in September/October, 1954, under the auspices of ECLA and FAO, to consider in detail the steps that need to be taken to encourage a development of the region's productive capacity commensurate with its future needs. Experts and technicians from Europe and North America played a leading part at this conference, during which special attention was paid to investigating the prospects of economic exploitation of the continent's most abundant reserve of potential papermaking material—its tropical hardwoods.

It is to the traditional pulp and papermaking centers that most countries will have to look for the necessary machinery, as well as for expert advice, and the task of the less developed countries will be simplified if equipment is forthcoming on suitable credit terms. Here interregional collaboration may facilitate the necessary contacts.

### *FAO*

At this particular juncture, the FAO can perhaps make the greatest contribution, since most countries are still in the reconnaissance stage—ascertaining the extent and suitability of their resources and the conditions under which they can be managed and successfully exploited.

One of the main obstacles to pulp and paper development in many countries is the lack of precise information concerning the extent and composition of their forests. Moreover, where forests are being or are about to be exploited for pulp it is important that the most up-to-date silvicultural methods be deployed if the forest capital is not to be depleted. Continuing emphasis needs to be placed also on the necessity for keeping production costs as low as possible by employing the technical knowledge and mechanical devices available for reducing the cost of extraction. The dissemination of information and advice on all these subjects forms part of the regular program of the Forestry Division of FAO. This program, which affords countries advice on such varied matters as the taking of forest inventories, seed selection, the prevention of forest fires, and the mechanization of logging techniques, assumes a new importance in the light of the world's future needs of pulp and paper.

In the projects which have been listed previously, it will be noticed that quite a number are based on coniferous plantations from fast-growing species. It is not surprising that these projects should loom large in a preliminary program, since the pulping of conifers presents today few problems of techniques

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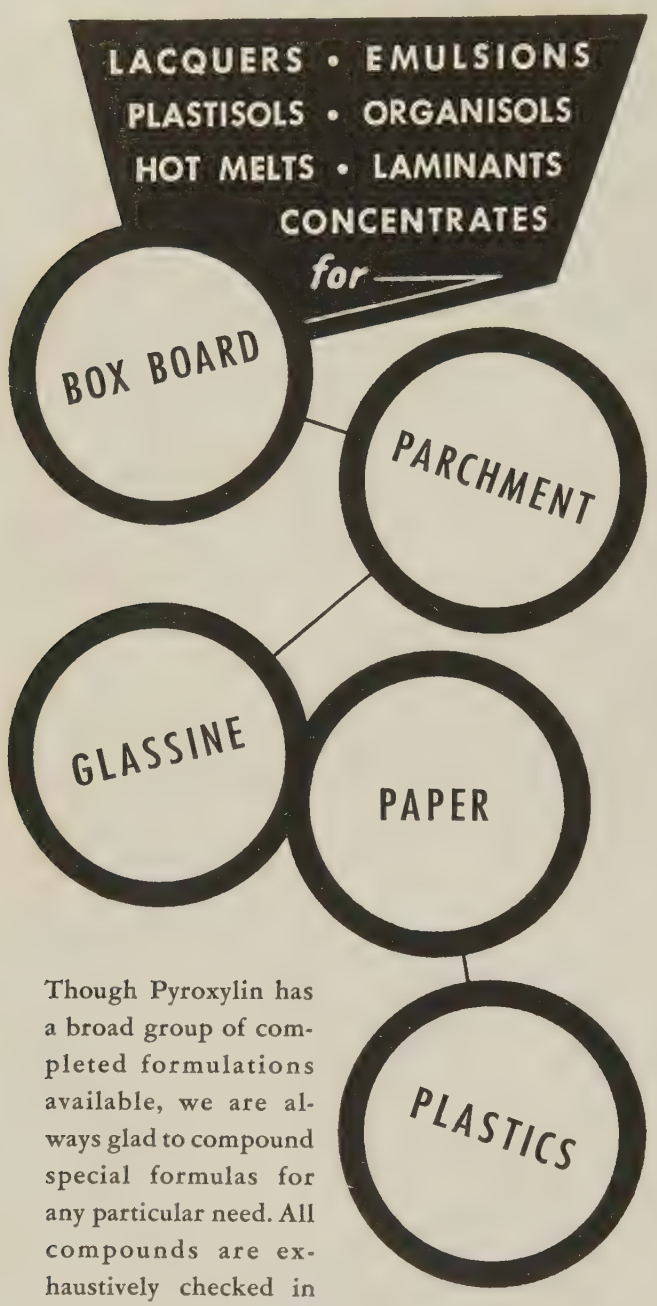


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and production costs. Moreover, it is clear that in the long-term, plantations will have their part to play in future pulp and paper developments. Their role is not limited to those countries where natural resources are scanty; even where there are adequate natural reserves, extraction costs may in some cases weigh the balance in favor of plantation-based developments. But plantations are not the answer to every materials problem. As time goes on research and experiment will be increasingly directed toward making use of abundant natural stands, especially of tropical woods, where they are found and in the composition in which they occur. It will be one of FAO's tasks to collate the experience gained to date concerning plantations so that it can advise, in those cases where current plantings are indicated as the basis of future pulping developments, on the best means of safeguarding against the dangers which have been mentioned in this survey.

It has been noted that the development of pulp and paper industries in the less-developed countries is often closely related to the present state of knowledge concerning the pulpability of various raw materials and the techniques and costs of various pulping processes. FAO should, therefore, continue to collect and disseminate to interested governments and organizations up-to-date information under these headings: in particular, increasing attention needs to be paid to the ascertainment of the economic size of mill appropriate to particular processes in the light of the various technological considerations involved.

Finally FAO will continue its assessment of the various projects reported to or suggested by its survey missions, singling out those of high promise whose prosecution, assuming that the survey teams' *prima facie* judgment is borne out by more detailed on-the-spot investigation, appears to hold out reasonable chances of early commercial success. By encouraging soundly-based projects, and by frankly pronouncing on more speculative ventures, it can help to insure that the next years shall bring ordered progress; the baleful consequences of uneconomic propositions—demands for higher protection, subsidies, tax concessions, trade restrictions, and other forms of artificial support, and the inevitable retarding of more healthy initiatives—can thus be guarded against.

This survey has sought to set out in a general way the nature and magnitude of the problem which faces the world today if paper shortages are not to hamper educational, cultural, and economic progress throughout the world. An indication has been given of the lines along which a solution may be sought. It should be emphasized once again that estimates of future demand are necessarily speculative, though based on those assumptions which appear most reasonable at the present time. Nor can there by any precision about our estimates of additions to productive capacity during the next decade.

An estimate of future prospects based on alternative assumptions might provide another picture, but it would be a picture that differed in detail rather than in essentials. For the broad trends are clear enough, as is the problem they pose.

In the last analysis it is a question of ensuring adequate supplies of a key commodity of vital importance to the cultural progress of mankind. Shall a shortage of this key commodity frustrate cultural progress for a majority of the world's peoples? Or shall its relative abundance serve as an important means of promoting that progress? This is the question at issue, and it is the question underlying the United Nations resolutions which have prompted international action in this field.

The main elements of a program of action to meet the problem have been indicated in this survey. The nature of the problem demands that it be kept under continuous review, and that future prospects be periodically reassessed in the light of the most recent information available concerning investment plans, technical possibilities, economic growth, educational, and cultural progress, and trends in pulp and paper production, consumption, and trade.

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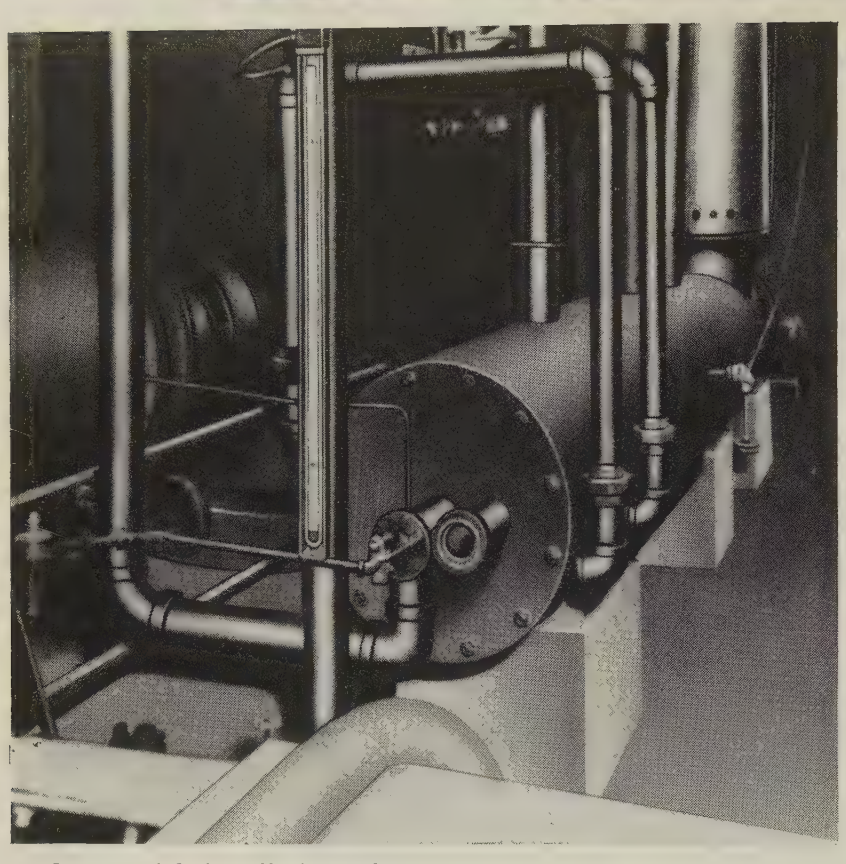

Commercial installation of Chemipulp-KC 2½-ton sulphur burner. Note the compact design as compared with conventional burner shown in the background.

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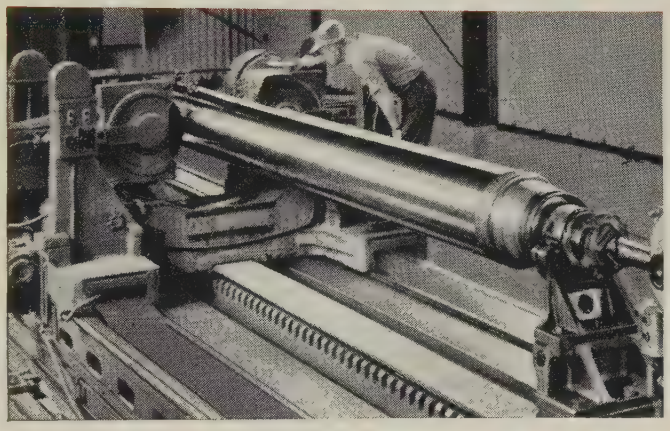

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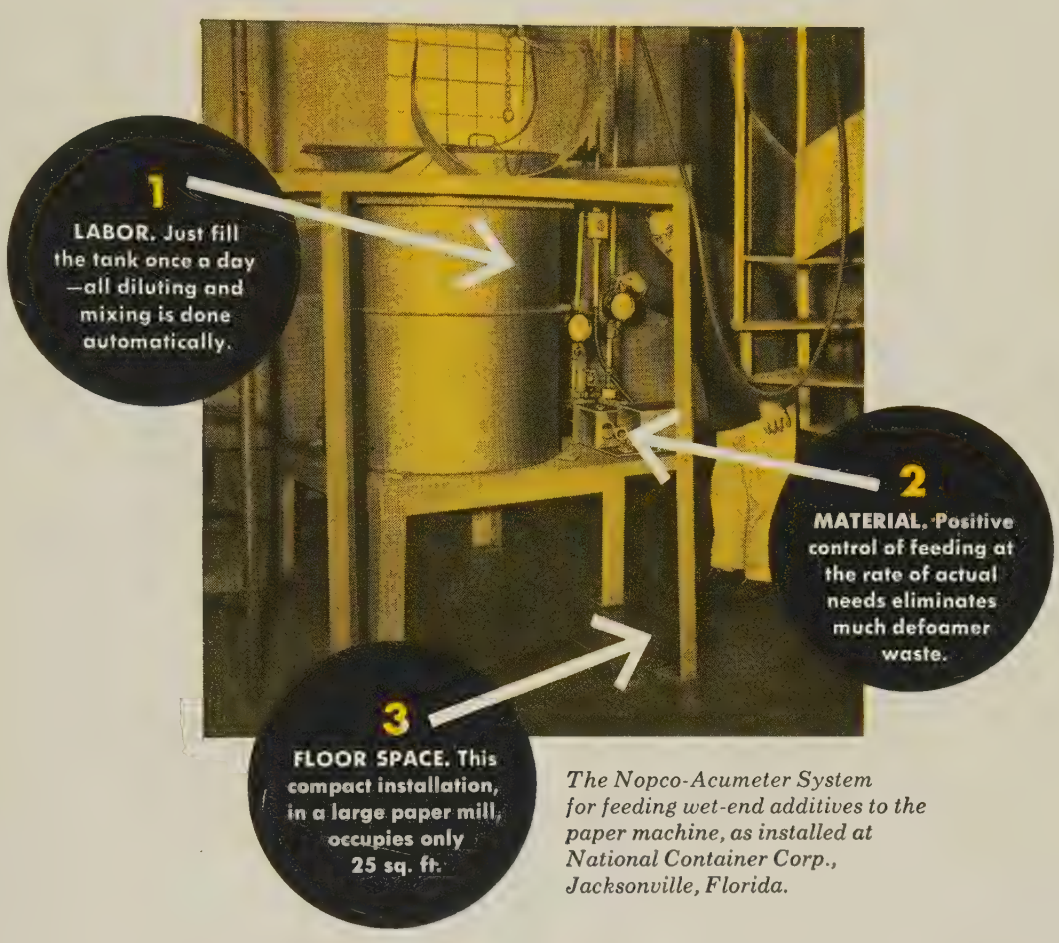
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For those mills without facilities for beater addition, another grade, Hydroseal '5' is proving just as effective. Its ability to improve surface finish of kraft liner board and similar grades is of particular interest. Hydroseal '5' is cooked at concentrations up to 5% prior to addition. This insures rapid dispersion with the furnish and eliminates the danger of "fish eyes" in head box additions. Write for technical data.

## CATIONIC STARCH OPENS NEW APPROACH TO WET END ADDITIONS

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A new kind of wet end additive, National's Cato Starch, is modernizing wet end additions. Cato is chemically modified through substitution of cationic groups in its molecular structure. These groups are electrochemically attracted to cellulose fibers which are receptive to cationic materials. As a result, fibers retain more starch. Fiber bonding is stronger. Less additive is needed to improve the quality of a variety of papers ranging from fine writing and printing to kraft grades.

Cato is one of the more recent products of National's continuing research and development work with basic starch and starch derivatives for the paper industry. It has been used with good success for improvement of such strength factors as mullen, pick, fold and tensile with sulfite, sulfate, soda and groundwood pulp, as well as with reclaimed stock and bogus kraft. Small quantities of Cato are effective. The greatest percentage increase generally occurs with the addition of from ¼ to 1% on the weight of dry pulp. Moreover, small amounts often give very excellent retention of fillers and pigments.

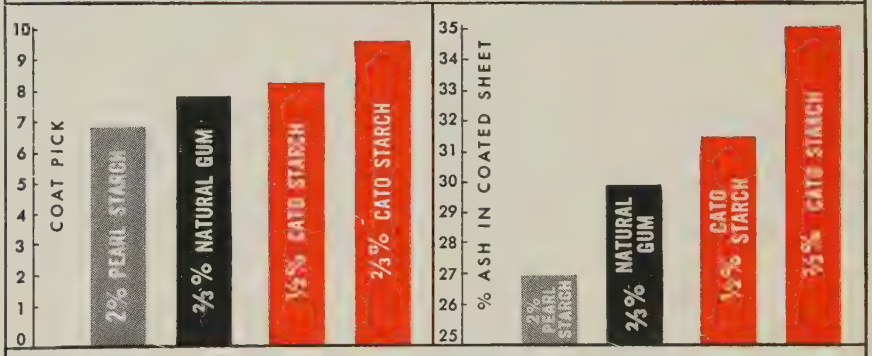
A growing list of mills is finding that Cato improves formation and reduces fuzz. Stock drains freely on the paper machine wire, often permitting faster machine speeds without impairing paper strength.

Cato is easily prepared by cooking at concentrations up to 3%. It may be added at a number of points on fourdrinier machines such as the fan pump, machine chest or headbox. On cylinder machines, Cato may be added to the stuff boxes.

For detailed information and technical assistance, contact your nearest National laboratory or sales office.

### COMPARATIVE STRENGTH AND OPACITY

(in terms of coat pick and ash content)




The values above were obtained under actual mill conditions. Cato was added at the wet end. Improved formation and increased pick strength in the coating base stock allowed for improved anchorage of the coating color and a resulting increase in coat pick. Since a constant coating weight was applied to the base stock, the increase in total ash may be attributed to increased retention of fillers at the wet end.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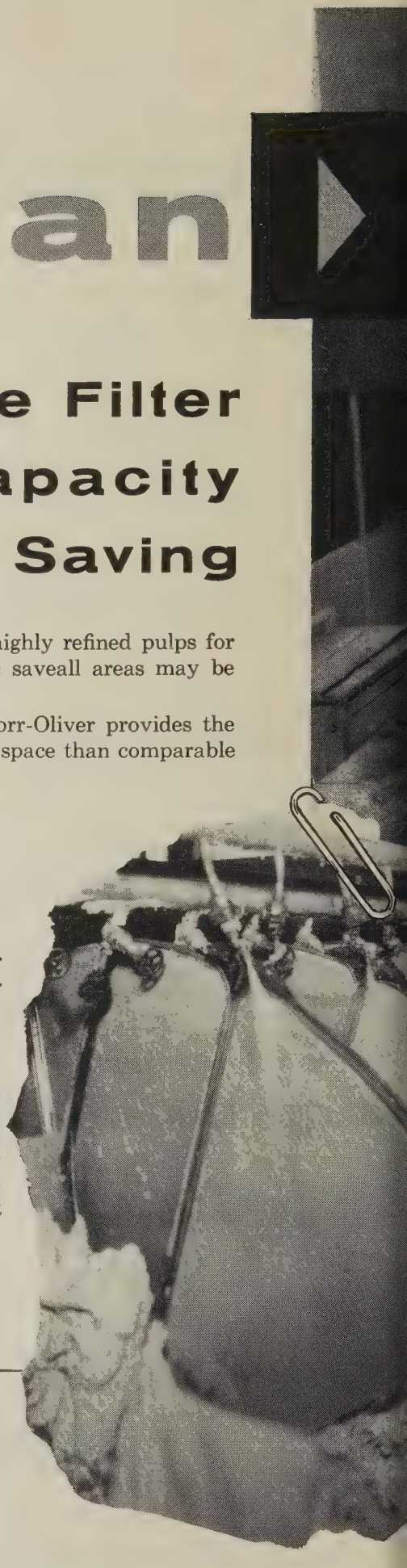
Important operating advantages include — easy, quick replacement of disc sectors. Thus, by keeping a few extra sectors as spares, down-time for periodic replacement of facing wire can be eliminated. By avoiding interruption of operation, problems of change over from white water to fresh water of different temperatures on the paper machine showers is prevented.

Hundreds of American Savealls are operating dependably in leading paper mills.

If you'd like more information on American Disc Type Savealls write for Bulletin 701-R — Dorr-Oliver Incorporated, Stamford, Conn. In Canada, 26 St. Clair Ave., East Toronto 5.



Sluicing jets cut under the sheets and peel or slice them off. The fine fibers and costly fillers are then returned to the stock chest with the sheet.

Illustrated is an American Disc Type Saveall installation at Scott Paper Company Mill in Chester, Pa. The 9 ft., 12 disc machine handles white water from their "Flying Scott", No. 7 machine. It is handling white water and sweetner as feed to the American Saveall, and the effluent filtrate contains only ½ pounds of fiber per 1000 gallons which is of a quality sufficiently high to permit it to be used as shower water.

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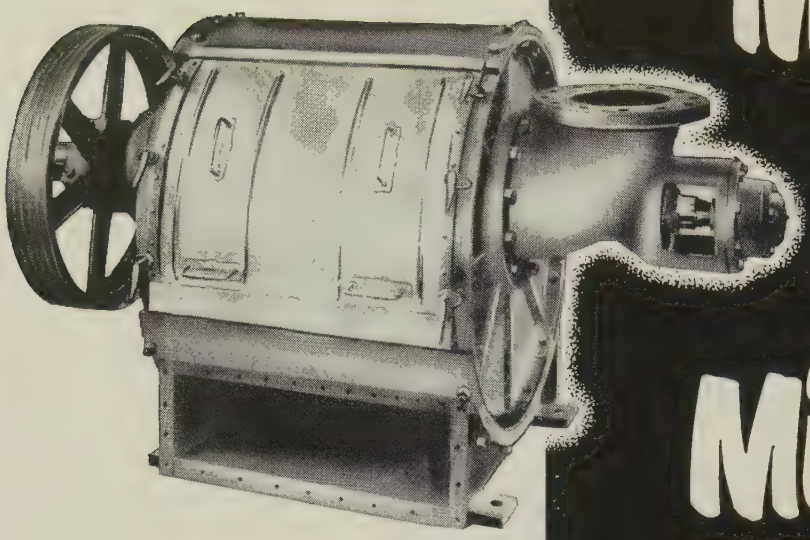

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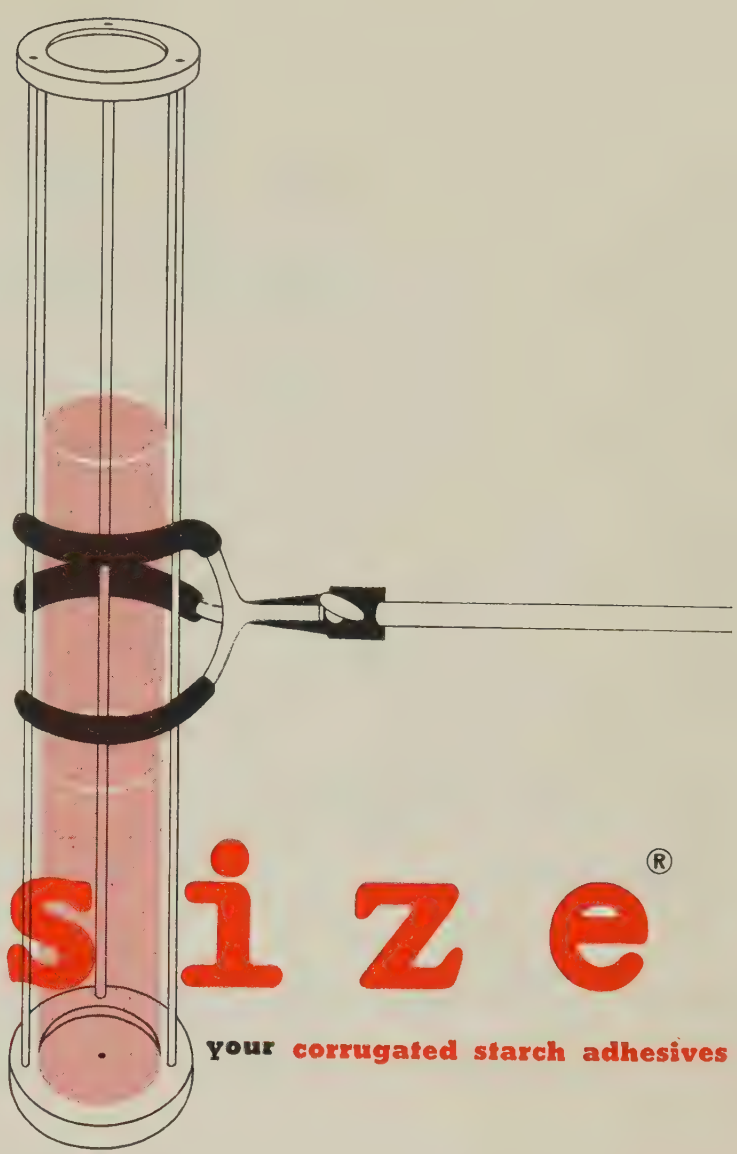

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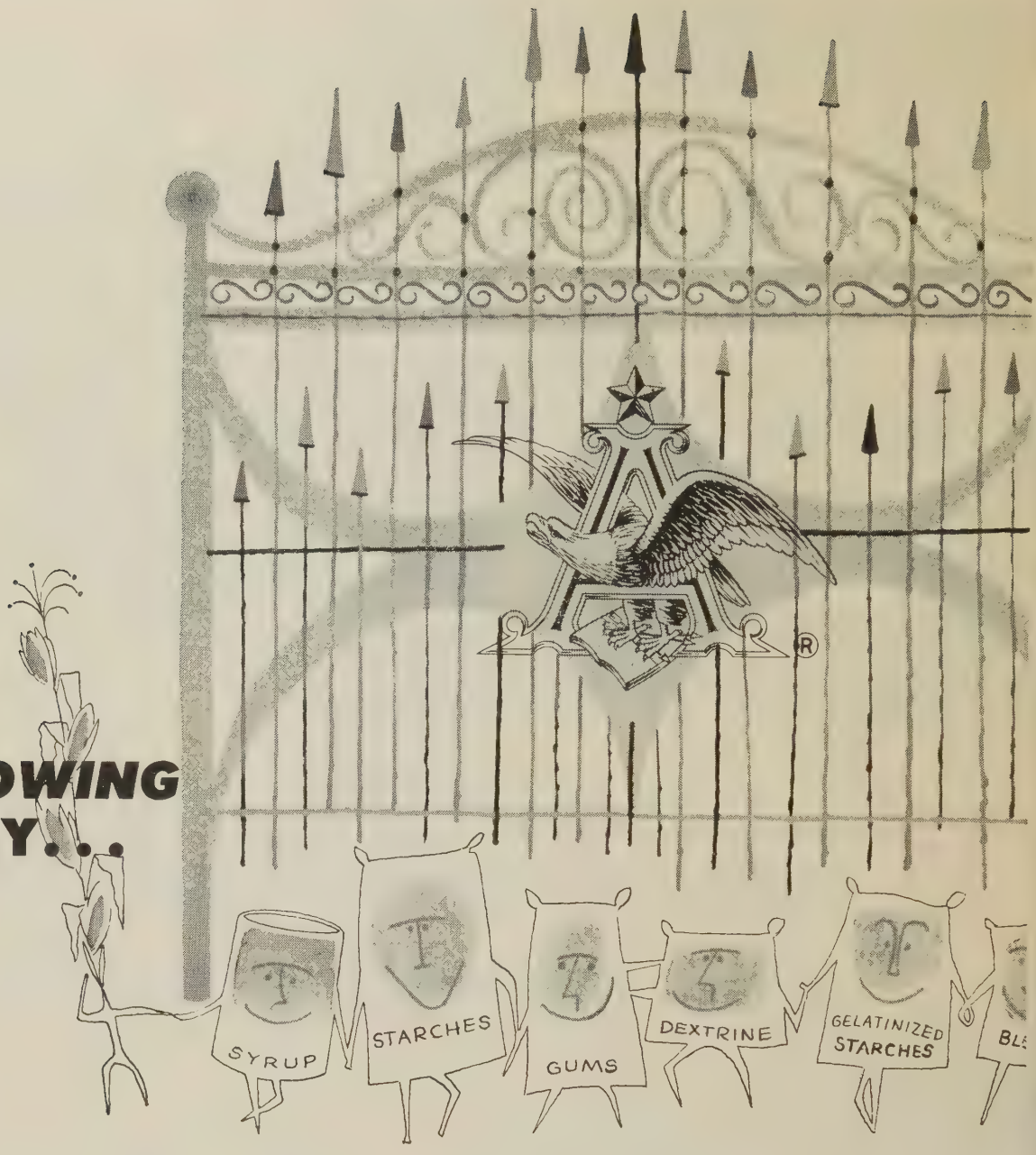


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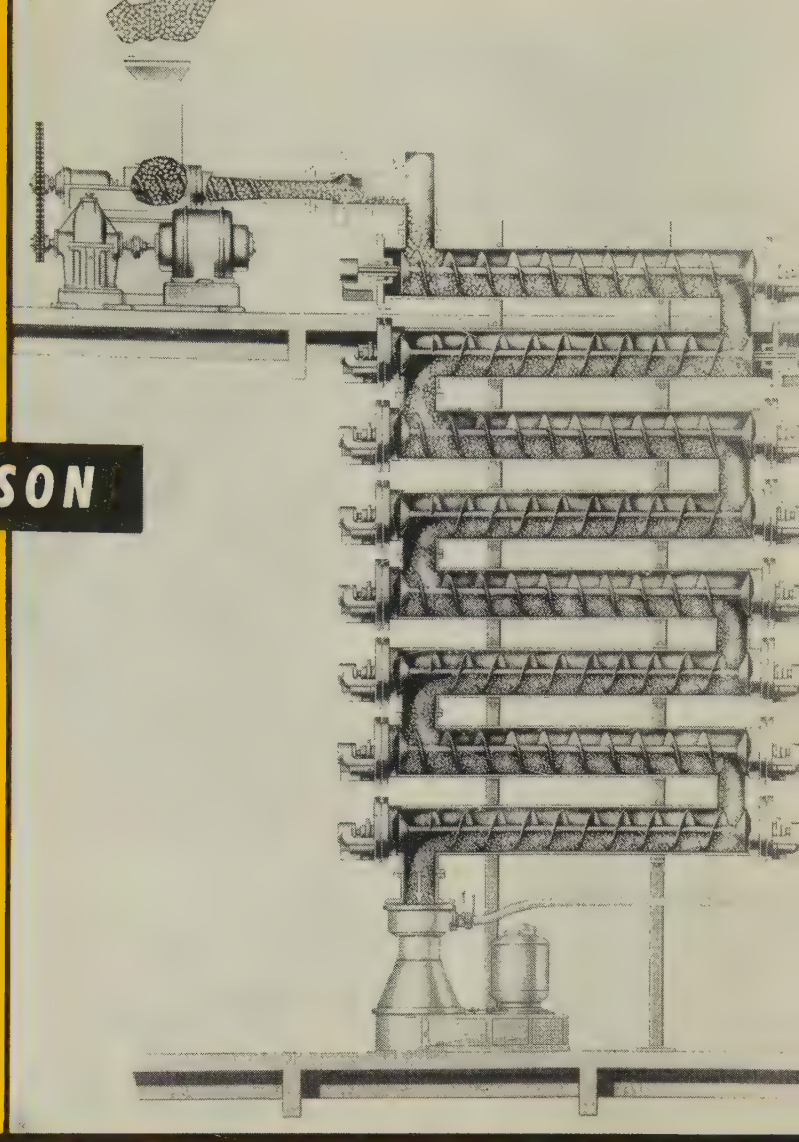

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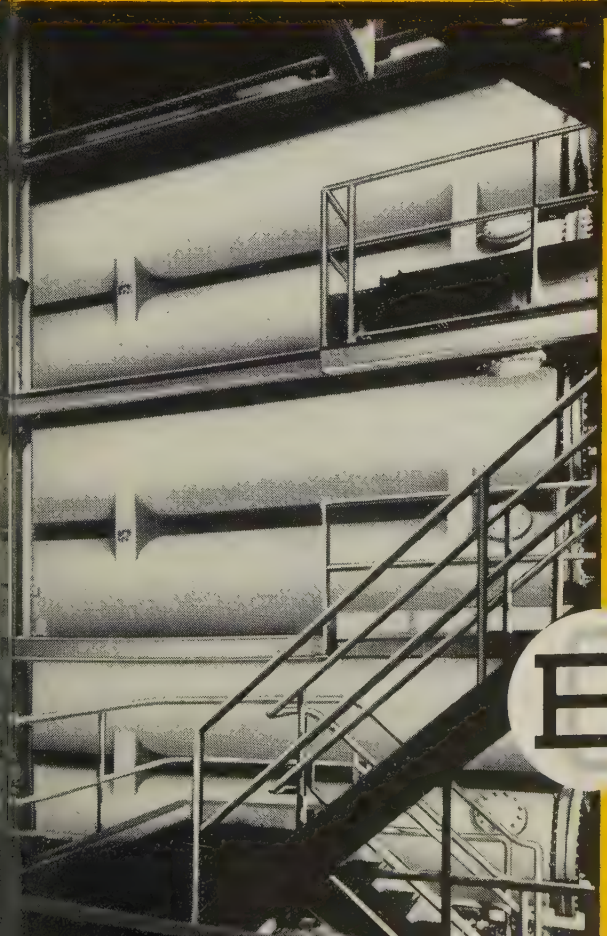

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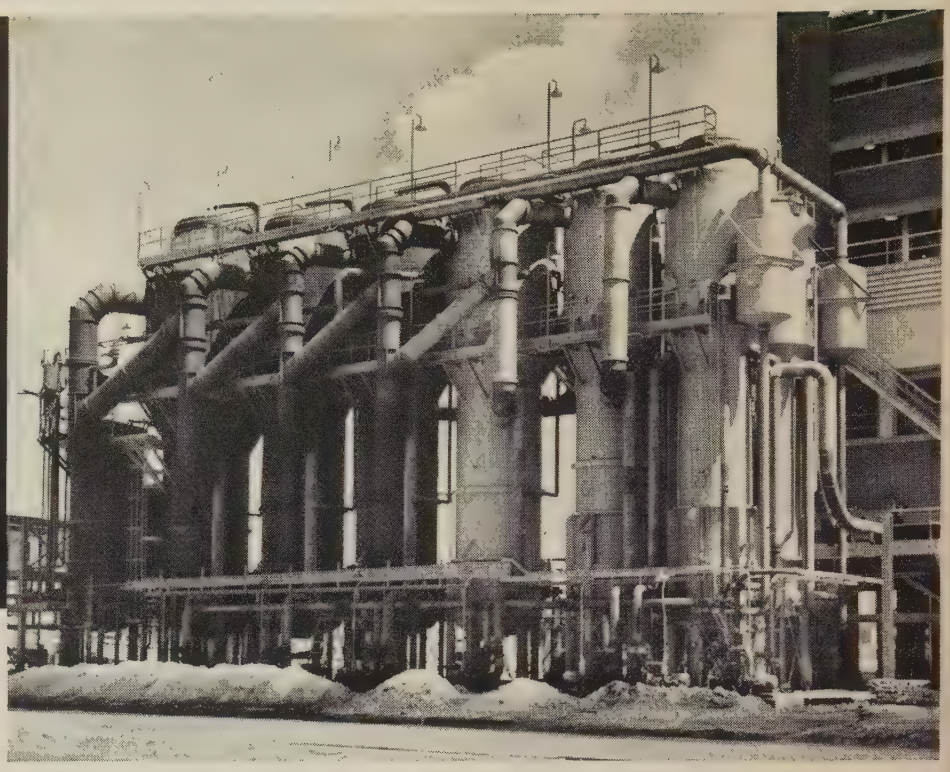
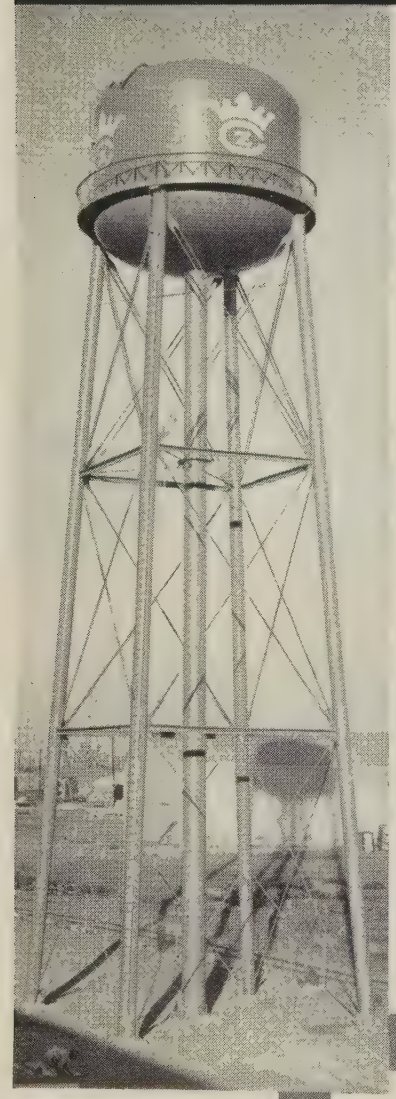
# A Common Sight to be Seen in the Paper Industry





◀ Left: 100,000-gal. Horton elevated tank located at the Crown Zellerbach Paper Company, East Los Angeles, California.

▲ Above: Conkey 8 Body Sextuple Effect Black Liquor Evaporators. They are code constructed throughout.

Increasingly, CB&I and Conkey equipment ARE sights that can be seen in the paper industry. Horton® elevated tanks, digesters and other welded steel plate structures and Conkey filters, evaporators and crystallizers are providing operators with the type of equipment that helps make profits.

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The Becco Pulp Dryer Steep Bleaching process with Hydrogen Peroxide is primarily applicable to bleached or partly bleached sulfite, kraft or soda pulps. Ask to see Becco technical consultants or send for Bulletin D-8 with complete description of process, typical mill results on various pulps schematics of process equipment, production chart and other helpful information.

Other Becco paper industry processes are described in the following bulletins: D-1 Becco Methods for Soda Pulp Bleaching, D-2 Becco Peroxide Bleaching Methods for Sulfite Pulps, D-3 Becco Procedures for Bleaching Kraft Pulps, D-4 Data on Flax Pulp Bleaching, D-5 Becco Peroxide Bleaching Methods for Semichemical Pulps, D-7 Becco Pulp Bleaching with Mixed Peroxides, D-10 Pretreatments for Groundwood Pulps, D-11 Becco Peracetic Acid 40% for Applications in Pulp and Paper Mills, D-12 Starch Solubilization with Becco Potassium Persulfate, D-13 Bleaching of Groundwood Pulp with Hydrogen Peroxide, D-14 Becco Hypochlorite-Peroxide Bleaching Process. *Write for complete bulletin list or any of the above.*

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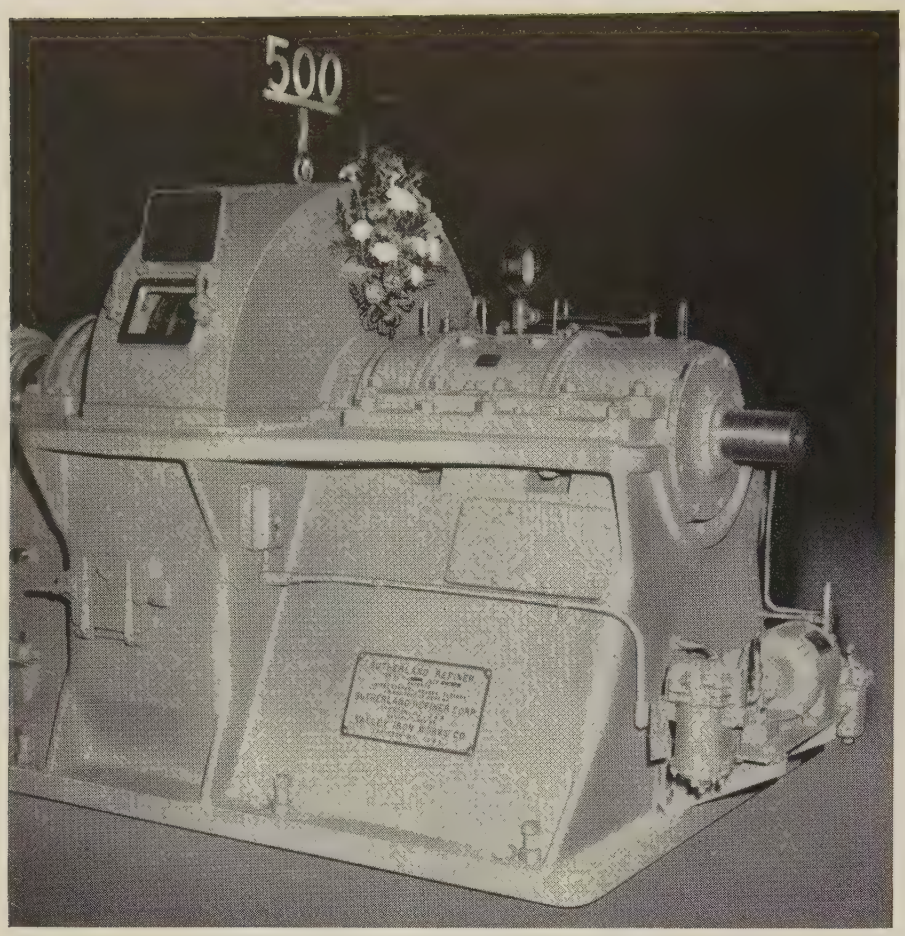


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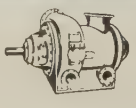

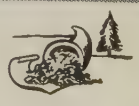

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T-7

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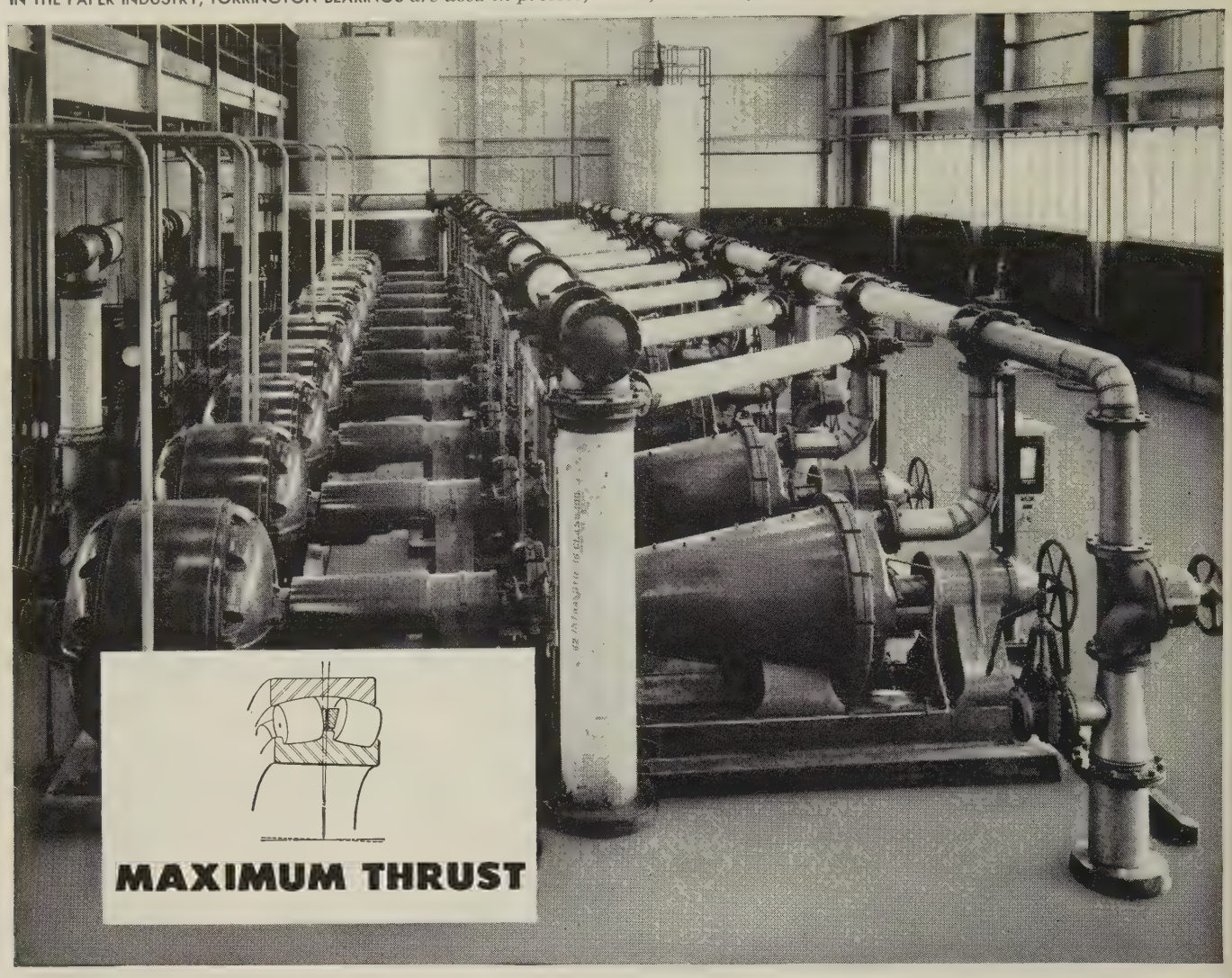


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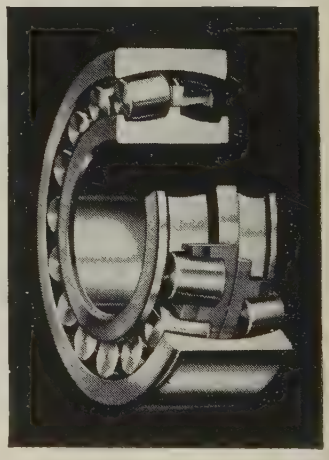

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# An Analytical Approach to the Problem of Drying of Thin Fibrous Sheets on Multicylinder Machines

A. H. NISSAN and W. G. KAYE

**The problem investigated here is the calculation of the temperature and moisture content of the sheet as it progresses through the drying section. It is shown that the problem is beset by several types of complexities and that radical simplifying assumptions have to be made before any solution—even a coarse approximation—can be achieved. On the basis of these primary assumptions, differential equations for heat and mass transfer are set up. It is shown that the integration of the equations can be done with several degrees of approximations depending on what accuracy is required and what effort can be expended. By making further or secondary assumptions, the first—coarse—approximation can be achieved very simply. As an illustration the calculation, to a first approximation, is carried out for a typical large newsprint machine. Many interesting results become apparent, perhaps the chief among them being the surprisingly good agreement with observations despite the many primary and secondary approximations used. Only next in importance is the indication given by these equations for the type and degree of accuracy of the data required, and which are at present not available, if a more precise calculation is to be attempted. Third, the results show a more complex variation of temperature and water content in the sheet than has been subject in textbooks and research journals. Finally, of course, if the method provides acceptable, it provides a means for predicting the effects of varying operating conditions, e.g. steam pressure, air, or sheet velocity, on the drying of the sheet in designing new machines or modifying old ones.**

THE purpose of this inquiry is to follow a square foot of a web of paper through the drying operation from the moment it touches the first cylinder until it leaves the last one and to determine its state of temperature and moisture content. Formulas have to be derived, applied to a typical machine, and the results so calculated checked against those which are obtained in practice. In effect, the problem then resolves itself into two: (1) a problem in heat transfer as heat flows from steam to paper and paper to air, and (2) a problem in mass transfer as water evaporates from the web. The main features of the physical laws governing both these problems are now sufficiently well known for the engineer's purposes envisaged here.

Yet, the actual determination of the temperature and moisture content at every point of the drying path is beset by many difficulties. These are probably best described under the headings: (1) difficulties due to the physical variability of all parameters in the equations developed, (2) mathematical difficulties, (3) difficulties due to ignorance. It is necessary to indicate what these difficulties are, and what steps are taken to overcome them, so that the basic assumptions and limitations of this inquiry are fully realized before the method itself and its results are subjected to scrutiny.

To appreciate the nature of the difficulty due to the physical variability of the parameters, the sheet of wet paper may be considered qualitatively as it passes over one cylinder and beyond. The sheet with, say, a known solid and water content per unit area and of known temperature approaches a cylinder of known surface temperature. One side of the sheet begins to heat up while the other side, being still open to the atmosphere, cools by evaporation, radiation, and conduction. Thus, immediately temperature and moisture gradients are set up in the direction of the depth of the sheet. Similarly, gradients are set up along the length of the sheet. After a short time the felt covers the outer side of the sheet and a new system of temperature and water content coordinates is established; this, in its turn, is changed again when the felt leaves the sheet, the sheet still clinging to the cylinder. Finally, the sheet leaves the cylinder and is free to dry on both sides in air. At every moment, not only the temperature and the moisture content of the web are changing, but the conditions of the air are changing too. Since the sheet is relatively free to shrink in the cross direction, even the solid content of the sheet (in pounds moisture-free solid per square foot) is continuously changing. The dimensions of the sheet are continuously variable too as the sheet loses water and becomes thinner. Indeed, an examination of the quantities required in the calculations—i.e., the solid and water content per unit area, the thickness, average density, average specific heat, linear speed and temperature of the sheet, the temperature and relative humidity of the air, and even the latent heat of the evaporating water—reveals that not one of these can be truly said to remain constant and on which the others can be based. Thus, even if there were no unknown factors—and there is a number, as will be seen presently—this state of complicated continuous variability presents difficulties in the mathematical expressions to be derived. These can only be overcome by a reasonable system of approximations.

The mathematical difficulties stem mostly from the physical variability of the parameters: if all the interactions and variations of parameters were to be derived then even though there is, perhaps, enough known to make it possible to set up the partial differential equations, these equations become unwieldy and intractable. Another source of mathematical difficulty is that some of the fundamental relationships are in the form of empirical equations with limitations and discontinuities —a not unfamiliar feature of engineering mathematics. Thus the equations to be adopted for the rate of evaporation in the constant rate period are limited to a mini-

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mum in width, another in length, and another in speed. Thirdly, the physical laws are somewhat complicated even with all parameters kept constant artificially. The rate of drying is constant at first, but as the moisture content decreases below a critical value it assumes a falling value. The drying rate is not independent of the length of the sheet of its velocity, being proportional to fractional powers of the length and the velocity. It is also dependent on the vapor pressure of the water, which is itself a complicated function of temperature. Since the temperature of the sheet itself depends on the rate of drying, the mathematical expression is not an easy one to manipulate without simplification.

Finally, there is the third difficulty of ignorance of the numerical values of many of the parameters which are required. Thus, while for the present practical engineering purposes an over-all coefficient of heat transfer from steam to web will be sufficient to estimate the temperature rise and fall in the web, not enough is known about the numerical values this coefficient takes under various conditions. The influence of the boundary layer of air on the sheet is an unknown factor. The heat and mass transfer between felt and sheet are undetermined. Temperature distributions within the sheet have to be guessed at—as it happens fairly shrewd guesses can be made, but nonetheless they remain guesses. A typical difficulty which is met near the end of the drying period and which is due to our ignorance is the following: a sheet of water will remain at the boiling point until it dries completely. A sheet of paper with water to solid ratio of 2 to 1 will probably do the same thing and therefore it can be safely assumed that the sheet will not exceed, say, 212°F. in temperature. On the other hand a moisture-free sheet has no such limitations imposed on it and can rise in temperature without restrictions according to the laws governing the heating of solids until chemical reactions intervene. But, at what water to solid ratio does the thermostatic effect of the water cease to operate and the sheet can assume higher temperatures than, say, 212°F.? In other words, suppose the sheet at a cylinder—near the end—appears, according to the calculations, to reach 212°F. half-way round the cylinder, when is it safe to assume that the sheet will remain at 212°F. (ignoring the rise in boiling point of water due to felt pressure) the heat simply going into evaporating the water without a rise in temperature, and when is it correct to assume that the sheet will reach higher temperatures?

## SIMPLIFYING ASSUMPTIONS

The manner of dealing with these initial difficulties adopted in this inquiry is as follows:

First, it is clear that it will not be possible to evaluate what takes place at any particular spot at a particular time. Instead it is hoped to determine *mean* values for both space and time. Thus, the mean values of properties and conditions right across the machine rather than conditions at the front, middle, or back of the machine will be evaluated and compared with practice. Similarly, the results obtained will be assumed to be, and compared with, the means obtained at any point over a long period of time, say a day or a week. In this way, the local and temporary fluctuations in temperature and speeds, in stock and air conditions, in cross currents, and in felt tension will be averaged out.

Second, to overcome the difficulties of continuous and discontinuous variations in the physical parameters the machine will be divided into small sections, the conditions in which will be constant to a degree acceptable in engineering practice. Thus, the drying machine is first divided into "cycles" of heating and drying. A cycle will contain one drying cylinder and one drying space and will begin when the web of paper first touches the cylinder and ends when it first touches the succeeding cylinder. Furthermore, each cycle will be divided into four "phases" as follows (see Fig. 1): Phase I begins when one side of the sheet first touches a cylinder and ends when the felt first touches the "outer" side of the sheet. Phase II begins when the felt first touches the sheet and ends when the felt leaves the sheet. Phase III begins when the felt leaves the sheet and ends when the sheet leaves the cylinder. Phase IV begins when the sheet leaves the cylinder and ends when it next touches a cylinder.

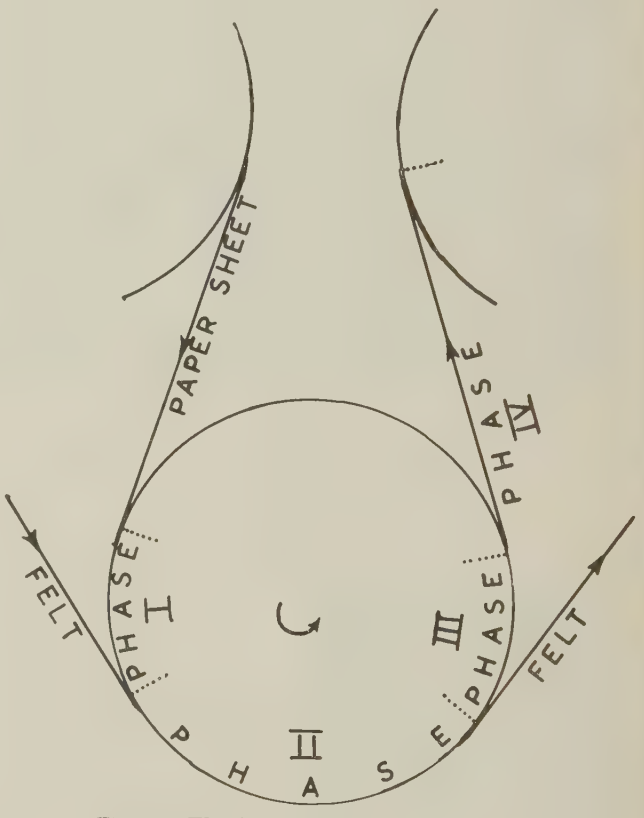


*Fig. 1. The four phases of a drying cycle*

Calculations will be made for each phase separately since conditions change abruptly as the sheet enters the different phases. Furthermore, it is sometimes found that even within one phase, conditions at the beginning are substantially different from those at the end. This, for example, occurs in phase IV—when the sheet is drying freely on both sides—near the middle of the drying section when temperatures are high and moisture content and thermal capacity of the sheet are low. In such circumstances, the phase of the cycle is further subdivided into two parts and calculations are made for the two parts in succession in order to obtain a

better approximation to reality than is possible with one averaging process for the whole phase. Finally a method of successive approximation is adopted within each part of each phase so that the approximation is made as close as is reasonably acceptable.

Third, although it is appreciated that all parameters vary with time and space, for the present practical purposes certain of these parameters are assumed constant. Thus, the moisture-free weight of the solid per unit area, the speed of the sheet, the conditions of the air, the temperature of the steam, the length of the sheet in phase IV, the thermal conductivity of the sheet, and the specific heats of cellulose and water are assumed constant. The sheet is also assumed to be a mixture of water and solids with properties of cellulose. These approximations are fully justified in view of the inexact knowledge available even about the most important of machine parameters—even cylinder surface temperatures are rarely known to a better accuracy than 5°F.

Fourth, it is realized that the over-all coefficient of heat transfer must vary as the sheet moves from one cycle to another and from one phase to another within the same cycle. Our ignorance of exact temperature conditions and expediency compels the adoption of a single value in the hope that it will agree with average conditions and this is done in the practical evaluation of conditions—though not in the more general derivation of the equations.

Fifth, the influence of the felt is not fully known. The device adopted here is to assume that the felt provides the mechanical pressure by means of which the over-all coefficient of heat transfer is realized, but takes no special part in water removal. Extra effects of water transfer, either by evaporation due to heat transmitted from the felt to the sheet or by liquid removal by capillarity, are purposely ignored. In other words, no account will be taken of liquid water being removed from the web by the felt or the cylinder itself by ways other than the normal mechanism of evaporation. Instead the felt is assumed to *retard* the removal of water vapor by the extra resistance it puts in its path. Thus the rate that would have obtained in free air is multiplied by a fraction less than one (0.1 actually) to account for the resistance of the felt to water vapor permeation. By comparing the results obtained by such calculations with those obtained in practice it is hoped to show what influence the felt in fact has. If this inquiry reveals that only a small proportion is evaporated into the air by normal mechanism, then there will be a big difference between the calculated and the observed water loss. This subject will be discussed in detail at the end of the paper.

Finally, except when the sheet is in free air—phase IV—the temperature is assumed constant with depth of the sheet. Thus the sheet is assumed to enter the air in phase IV with both surfaces at the same temperature. When the sheet is cooling by evaporation in phase IV a parabolic distribution of temperature with depth is assumed as will be discussed at the appropriate place.

These, then, are the general simplifying assumptions made. Others of specific and local nature will be made and indicated where they are found necessary.

## DERIVATION OF FORMULAS

### *Temperature of the Sheet*

In phases I, II, and III heat will flow from the cylinder into the paper, so that, for each phase, the heat input equals the total heat output. Since the over-all evaporation of water in these phases is small, the loss of heat and of water by evaporation is ignored and calculations are made on the basis that all heat input is utilized in raising the temperature of the sheet. This in effect means an adjustment in the value of $H$, the over-all coefficient of heat transfer in equation (1) and since this coefficient is not known with any great certainty the adjustment is probably within the errors of estimation.

$$M(\gamma + p)dt = H(t_c - t)d\theta \qquad (1)$$

where

$M$ = weight of moisture-free solids in pounds per square foot
$\gamma$ = specific heat of solids, B.t.u. per pound per °F.
$p$ = water to solid ratio
$H$ = over-all coefficient of heat transfer, B.t.u. per square foot per second per °F.
$t_c$ = cylinder (steam) temperature, °F.
$t$ = sheet temperature, °F.
$\theta$ = time, seconds

or if

$$M' = M(\gamma + p)$$

$$\int_{t_0}^{t_{\Delta\theta}} \frac{dt}{t_c - t} = \frac{H}{M'} \int_o^{\Delta\theta} d\theta \qquad (2)$$

and

$$t_{\Delta\theta} = t_c - \left[(t_c - t_o) \exp\left(-\frac{H\Delta\theta}{M'}\right)\right] \qquad (3)$$

where the suffix $o$ denotes conditions at time zero for a phase or a cycle; and suffix $\Delta\theta$ denotes conditions after passage of $\Delta\theta$ sec. in phases I, II, or III. (To avoid confusion the suffix $\delta\theta$ is used for conditions after a passage of $\delta\theta$ seconds in phase IV.)

Thus for phases I, II, and III knowledge of the initial temperature of the sheet and of the steam pressure or temperature (assumed condensing saturated steam) and of the over-all coefficient of heat transfer should be sufficient for an easy estimation of the temperature at the end of each phase, $t_{\Delta\theta}$, by means of equation (3).

In phase IV the sheet loses both water and heat to the surrounding air. Considering a strip 1 ft. wide and 1 ft. long, the sheet will again be assumed to be with $M$ lb. per sq. ft. solids and $W = pM$ lb. per sq. ft. water at temperature $t_{\Delta\theta}$ having reached that temperature at the end of phase III as shown by equation (3). Then let

$$Q = Q_C + Q_R + Q_E \qquad (4)$$

$$\left.\begin{aligned} Q_C &= -h(t_{\Delta\theta} - t_{db}) \\ &= -\frac{0.53}{3600} V^{0.78}(t_{\Delta\theta} - t_{db}) \end{aligned}\right\} \qquad (5)$$

$$Q_R = -\frac{0.172 \times 0.9}{3600}\left[\left(\frac{t_{\Delta\theta} + 460}{100}\right)^4 - \left(\frac{t_{db} + 460}{100}\right)^4\right] \qquad (6)$$

$$Q_E = (dw/d\theta)L_t \qquad (7)$$

where

$Q$ = total heat transfer between sheet and air, B.t.u. per square foot per second
$Q_C$ = heat transfer by convection, B.t.u. per square foot per second

$Q_R$ = heat transfer by radiation, B.t.u. per square foot per second
$Q_E$ = heat transfer by evaporation, B.t.u. per square foot per second
$h$ = over-all coefficient of heat transfer by conduction from sheet to air moving with velocity $V$ ft. per sec. $= a + b\,V^n$ where $a = 0$, $b = (0.53/3600)$, $n = 0.78$ for conditions in medium and high speed machines, B.t.u. per square foot per second per °F.
$t_{db}$ = dry bulb temperature of air, °F.
$V$ = velocity of air, feet per second
$L_t$ = latent heat of evaporation of water, at temperature $t$ °F., B.t.u. per lb.

Equations (5) and (6) will be found in most books on heat transfer or handbooks on chemical engineering heat transfer or handbooks on chemical engineering (*1*).

Provided the length and width of the sheet are more than 1 ft. and the sheet speed is more than, say, 200 f.p.m. $(dw/d\theta)$ the rate of water evaporation (in pounds per square foot per second can be calculated for the constant rate period from Powell and Griffiths' formula (*2*), changed to foot-pound-second units in equation (8).

## LIST OF SYMBOLS USED

$A$ material constant equal to $[k/(\overline{\rho\gamma})]$.
$B$ a mathematical function equal to $[V^2(Q/Yk)]$.
$F$ used as a suffix to denote conditions in the falling rate period of evaporation.
$H$ over-all coefficient of heat transfer between steam and sheet, B.t.u. per sq. ft. per sec. per °F.
$h$ over-all coefficient of heat transfer by conduction from sheet to air moving at $V$ ft. per sec $(= a + bV^n$ where for medium and high-speed machines $a = 0$; $b = 0.53/3600$; $n = 0.78)$, B.t.u. per sq. ft. per sec. per °F.
$k$ thermal conductivity, B.t.u. per ft. per sec. per °F.
$L$ latent heat of evaporation for water, B.t.u. per lb.
$l$ length of sheet, ft.
$M$ weight of dry solid per unit area of sheet, lb. per sq. ft.
$M'$ a mathematical function equal to $M\,(\gamma + p)$.
$P_a$ partial pressure of water in air, mm. Hg.
$P_w$ vapor pressure of water at surface temperature, mm. Hg.
$p$ ratio of weight of water to weight of dry solid of the sheet $= W/M$, dimensionless.
$Q$ rate of total heat transfer per unit area, B.t.u. per sq. ft. per sec.
$Q_C$ rate of heat transfer per unit area due to conduction, B.t.u. per sq. ft. per sec.
$Q_E$ rate of heat transfer per unit area due to evaporation, B.t.u. per sq. ft. per sec.
$Q_R$ rate of heat transfer per unit area due to radiation, B.t.u. per sq. ft. per sec.
$t$ temperature, °F.
$t_c$ temperature of the cylinder (or steam), °F.
$t_{db}$ dry bulb temperature of air, °F.
$t_o$ temperature of the sheet at zero time, °F.
$V$ velocity, ft. per sec.
$W$ weight of water per unit area of sheet, lb. per sq. ft.
$W_c$ weight of water per unit area of sheet at the critical point (when evaporation ceases to be at a constant rate and begins to follow a law of falling rate of evaporation with water content), lb. per sq. ft.
$x,y,z$ Cartesian coordinates for the sheet in the directions of width, depth, and length respectively, ft.
$Y$ half the depth or thickness of the sheet, ft.
$\gamma$ specific heat of the solids in the sheet, B.t.u. per lb. per °F.
$\Delta$ denotes a finite increment in a quantity when the sheet is in contact with the cylinder, i.e., in phases I, II, and III of a drying cycle.
$\delta$ denotes a finite increment in a quantity when the sheet is not in contact with the cylinder, i.e., in phase IV of the drying cycle.
$\theta$ time, sec.
$\rho_l$ density of the liquid (water) in the sheet, lb. per cu. ft.
$\rho_l$ density of the solid in the sheet, lb. per cu. ft.
$(\overline{\rho\gamma})$ the mean of the product of density and specific heat $= \left(\frac{\rho_s\gamma + \rho_l p}{1 + p}\right)$, B.t.u. per cu. ft. per °F.
$\sigma$ the rate of change of temperature with time $= (dt/d\theta)$, °F. per sec.

$$\frac{dw}{d\theta} = -\frac{2.12 \times 10^{-7}(30.5)^{0.77}(30.5)(P_w - P_a)[1 + 0.121(30.5V)^{0.55}]}{453} \quad (8)$$

where
$P_w$ = vapor pressure of water at surface temperature of the sheet, millimeters Hg
$P_a$ = partial pressure of water in air, mm. Hg

From the basic equations (4) to (8) the temperature of the sheet may be derived as follows:

$$\frac{k\,dt}{dy} = -Q \quad (9)$$

and

$$k\left(\frac{d^2t}{dy^2} + \frac{d^2t}{dz^2}\right) = (\overline{\rho\gamma})\frac{dt}{d\theta} \quad (10)$$

assuming

$$\frac{dt}{dx} = \frac{d^2t}{dx^2} = 0$$

where
$k$ = thermal conductivity, B.t.u. per foot per second per °F.
$(\overline{\rho\gamma})$ = the mean product of density and specific heat of the sheet $= [(\rho_s\gamma + \rho_l p)/(1 + p)]$ where $\rho_s$ = density of solid and $\rho_l$ density of liquid (both in pounds per cubic feet), B.t.u. per cubic foot per °F.
$x,y,z$ = the coordinates of length in the direction of width, depth, and length of the sheet respectively, feet

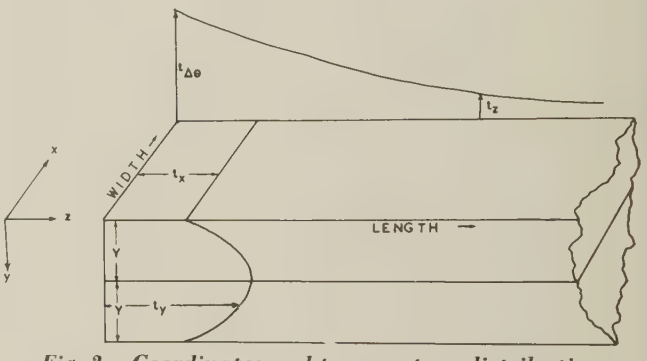


***Fig. 2. Coordinates and temperature distribution envisaged in a sheet in phase IV of a drying cycle***

Figure 2 indicates the dimensions and temperature of the sheet as envisaged.

Since

$$dz = V\,d\theta \quad (11)$$

then if

$$\frac{k}{(\overline{\rho\gamma})} = A \text{ and } \left(\frac{dt}{d\theta}\right) = \sigma$$

$$A\left[\frac{d^2t}{dy^2} + \frac{1}{V^2}\frac{d\sigma}{d\theta}\right] = \sigma \quad (12)$$

The sheet is assumed to possess symmetry about its neutral plane—i.e., about a plane midway between and parallel to its outer surfaces—since originally both surfaces were assumed to be at $t_{\Delta\theta}$ and conditions are assumed to be the same on both sides of the sheet. Therefore $(dt/dy)_{y=Y} = 0$ where $Y$ is the half thickness of the sheet in feet and since $(dt/dy)_{y=0} = -(Q/k)$ from equation (9), it is legitimate to assume for such a thin body that $(dt/dy)$ is linear with $y$ and $(d^2t/dy^2) = Q/Yk$. In order to utilize this expression for $(d^2t/dy^2)$

without unduly complicating the formulas it is necessary for $Q$, $Y$, and $k$ to remain constant. It is therefore necessary to work with a length $z$ of the sheet for which no appreciable change in these values occurs. For such short lengths

$$\frac{d\sigma}{d\theta} - \frac{V^2}{A}\sigma + B = 0 \qquad (13)$$

where

$$B = V^2\left(\frac{Q}{Yk}\right) \sim \text{constant.}$$

Integrating (13) and inserting boundary conditions,

$$\frac{dt}{d\theta} = \sigma = \frac{AB}{V^2} = \frac{Q}{(\overline{\rho\gamma})}\frac{1}{Y} \qquad (14)$$

as

$$Y = \frac{M}{2}\left(\frac{1}{\rho_s} + \frac{p}{\rho_l}\right) \qquad (15)$$

$$\frac{dt}{d\theta} = \frac{2Q}{M(\overline{\rho\gamma})\left(\frac{1}{\rho_s} + \frac{p}{\rho_l}\right)} \qquad (16)$$

Equation (16) gives the rate of temperature loss at the beginning of phase IV in °F. per second. This rate would continue to hold if $Q$ and $p$ remained constant. Neither, however, remains constant since water is continuously evaporating.

To introduce the full expression for $Q$ in equation (13) would make it unmanageable. Therefore a mean value for $(dt/d\theta)$, over the whole or *only part of phase IV if the temperature drop is too large*, is obtained by calculating the value of $(dt/d\theta)$ at the beginning and end of phase IV and taking an average. Further improvements in the accuracy may be gained by successive approximation. Thus, in detail, the method of calculating the temperatures in phase IV is as follows:

1. Calculate for condition $t_{\Delta\theta}$

$$Q_E = (dw/d\theta)_{\Delta\vartheta} \cdot L_{\Delta\theta} \qquad (7)$$

and similarly $Q_C$ and $Q_R$. Then

$$Q_{\Delta\theta} = (Q_C + Q_R + Q_E)_{\Delta\vartheta} \qquad (4)$$

$$\left(\frac{dt}{d\theta}\right)_{\Delta\theta} = \left[\frac{2Q}{M(\overline{\rho\gamma})\left(\frac{1}{\rho_s} + \frac{p}{\rho_l}\right)}\right]_{\Delta\theta} \qquad (16)$$

Taking

$$\delta\theta = \frac{\text{Length of whole (or part) of phase IV}}{V} \qquad (17)$$

$$t_{\delta\theta} = t_{\Delta\theta} + \left(\frac{dt}{d\theta}\right)\delta\theta \qquad (18)$$

2. Repeat the three steps indicated by equations (7), (4), and (16) for condition $t_{\delta\theta}$ and obtain

$$\left(\frac{dt}{d\theta}\right)_{\delta\theta} = \left[\frac{2Q}{M(\overline{\rho\gamma})\left(\frac{1}{\rho_s} + \frac{p}{\rho_l}\right)}\right]_{\delta\theta} \qquad (16)$$

Then a second approximation of $t_{\delta\theta}$ may be obtained from averaging the two rates and calculating the drop:

$$\left(\overline{\frac{dt}{d\theta}}\right) = {}^1/_2\left[\left(\frac{dt}{d\theta}\right)_{\Delta\theta} + \left(\frac{dt}{d\theta}\right)_{\delta\theta}\right] \qquad (19)$$

and

$$(\overline{t_{\delta\theta}}) = t_{\Delta\theta} + \left(\overline{\frac{dt}{d\theta}}\right) \cdot \delta\theta \qquad (20)$$

This process can be repeated to obtain further precision in $(\overline{t_{\delta\theta}})$ but it is important to realize that if, in fact, $Q_{\Delta\theta}$ differs very greatly from $Q_{\delta\theta}$ such successive approximations do not give an accurate result. The only method is to split phase IV into two successive halves and treat each half independently and add the results both for the water evaporation (see below) and temperature drop. This method of dividing phase IV into two—or more—portions and calculating for each part separately also affords a criterion for judging whether variations in $Q$ are in fact too large or not: only if calculations by parts of phase IV agree satisfactorily with calculations for taking the whole of phase IV in one step should the variations in $Q$ be considered to be satisfactorily low to justify the shorter method of treating phase IV as one unity.

***Water Content of the Sheet***

The rate of evaporation is calculated by equation (8) and treated as follows:

*Constant Rate Period*

Phase I. $(dw/d\theta)$ is calculated by means of equation (8) for the mean temperature of phase I. (The temperatures are not known with sufficient accuracy to justify the more rigorous method of averaging $(P_w - P_a)$ by means of integrating it as a function of temperature.) Then

$$\Delta W_I = \left(\frac{dw}{d\theta}\right)\frac{(\text{length of phase I})^{0.77}}{V} \qquad (21)$$

where $\Delta W_I$ = water removed from the sheet in phase I, pounds per square foot

Phase II is treated as phase I except that (1) $v = 0$ and (2) the result of equation (21) is multiplied by a factor to account for the resistance of the felt to water permeation.

Phase III is treated as phase I in all respects.

Phase IV. The method of successive approximations is used whereby the rate of evaporation is calculated at the beginning and end of the phase (or part of phase) and a mean rate $(\overline{dw/d\theta})$ is taken where

$$\left(\overline{\frac{dw}{d\theta}}\right)_{\delta w} = {}^1/_2\left[\left(\frac{dw}{d\theta}\right)_{\Delta} + \left(\frac{dw}{d\theta}\right)_{\delta\theta}\right] \qquad (22)$$

then

$$\delta w = 2(\overline{dw/d\theta})\left\{\frac{(\text{length of phase IV})^{0.77}}{V}\right\} \qquad (23)$$

since evaporation is from two surfaces.

Again, checks are made that the total loss of water in phase IV calculated by taking it in two successive halves check the total calculated by taking phase IV in one unit. If the two do not agree then phase IV must be partitioned. This is necessary between the middle and end of the drying section when the temperatures are high and water content and thermal capacity of the sheet are low.

*Falling Rate Period*

The shape of the curve for $(dw/d\theta)$ versus $W$ in the falling rate period is different for different materials, but for practical purposes the curve may be assumed to be linear up to the critical moisture content $W_c$ and

passing through the origin. Thus for all phases the treatment remains the same as discussed in the preceding paragraphs except that for $(dw/d\theta)$ should be substituted $(dw/d\theta)_F$ where

$$(dw/d\theta)_F = \frac{W}{W_c}\left(\frac{dw}{d\theta}\right) \qquad (24)$$

## APPLICATION OF FORMULAS

The formulas developed in the previous section were applied to the conditions obtaining in a typical, medium speed fourdrinier machine making news and magazine paper. The average value of pertinent data for 1 week were as follows:

**Measured Data (Average of daily measurements for 1 week)**

| | | |
|---|---|---|
| Paper | Basis weight | 49.8 g. per sq. m.<br>$9.56 \times 10^{-3}$ lb. per sq. ft. |
| | Water content at entry | = 67.2% |
| | Water to solid ratio | = 2.05 |
| Air | Temperature of incoming air | = 84.4°F. |
| | Relative humidity of incoming air | = 54.4% |
| | Temperature of outgoing air | = 122.8°F. |
| | Relative humidity of outgoing air | = 63.5% |
| Machine | Number of cylinders | = 37 |
| | Diameter of 1st cylinder | = 3 ft. |
| | Diameter of remaining 36 | = 5 ft. |
| | Speed of sheet | = 912 f.p.m.<br>= 15.2 f.p.s. |
| | Time of passage of sheet through entire section | = 31.3 sec. |
| | Length of sheet in contact with cylinder | = 9.92 ft. |
| | Length of felt in contact with cylinder | = 7.85 ft. |
| Steam | Temperature in 1st section (baby + 10 cyl.) | = 218°F. |
| | Temperature of remaining 25 cylinders | = 232°F. |
| | 36th cylinder | = sweat cylinder |

**Basic Calculated Quantities (For all cycles beyond the "baby cylinder")**

| | | |
|---|---|---|
| Length of phase | I | = 1.04 ft. |
| | II | = 7.85 ft. |
| | III | = 1.04 ft. |
| | IV | = 3.10 ft. |
| Time in phase | I | = 0.0684 sec. |
| | II | = 0.516 sec. |
| | III | = 0.0684 sec. |
| | IV | = 0.204 sec. |

**Arbitrary Assumptions**

| | |
|---|---|
| Over-all coefficient of heat transfer | = 60 B.t.u. sq. ft. per hr. per °F.<br>= 1/60 B t.u. sq. ft. per sec. per °F. |
| Critical water to solid ratio | = 0.40 |
| Resistance factor of felt | = 0.10 |

Calculations were made step by step starting with the sheet touching the first cylinder immediately after the baby cylinder. No exact calculations were made for the baby cylinder as conditions are somewhat vague in that region; allowance was however made by taking the sheet temperature as having reached 100°F. and its water to solid ratio as having fallen to 2.01. The results of the step-wise calculations are summarized in Figs. 3, 4, and 5. In Fig. 6 is given the contribution of each phase, summed for the whole drying section.

## VALIDITY OF THE ANALYSIS

Before discussing the results, it is necessary to inquire, in view of the many simplifications made, whether the

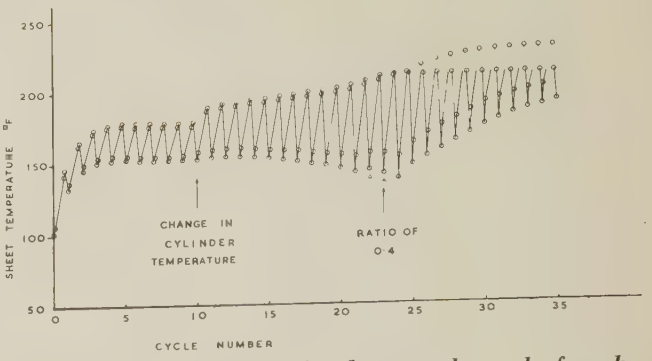


*Fig. 3. Temperature of the sheet at the end of each phase in the drying section*

results are sufficiently valid as to be worthy of discussion. Equation (1) was based on the assumption that

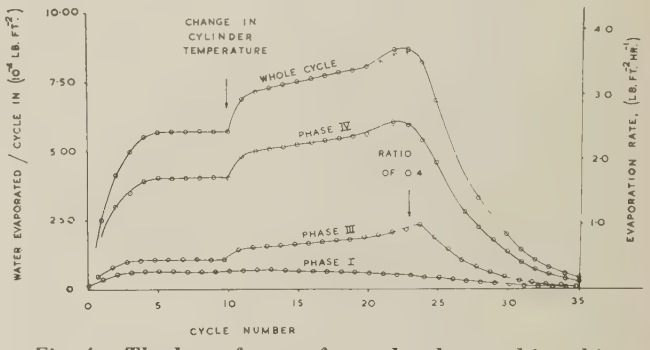


*Fig. 4. The loss of water from the sheet achieved in each of the phases I, III, and IV and by each cycle of the drying section*

the temperature rise was solely due to sensible heat—i.e., the contribution of the first three phases to water

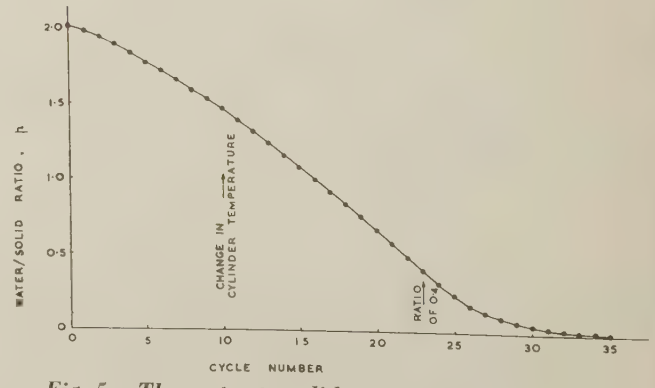


*Fig. 5. The water to solid ratio at the end of each cycle in the drying section*

removal was purely a heating effect. This basic idea of suppressing the contribution to water removal was

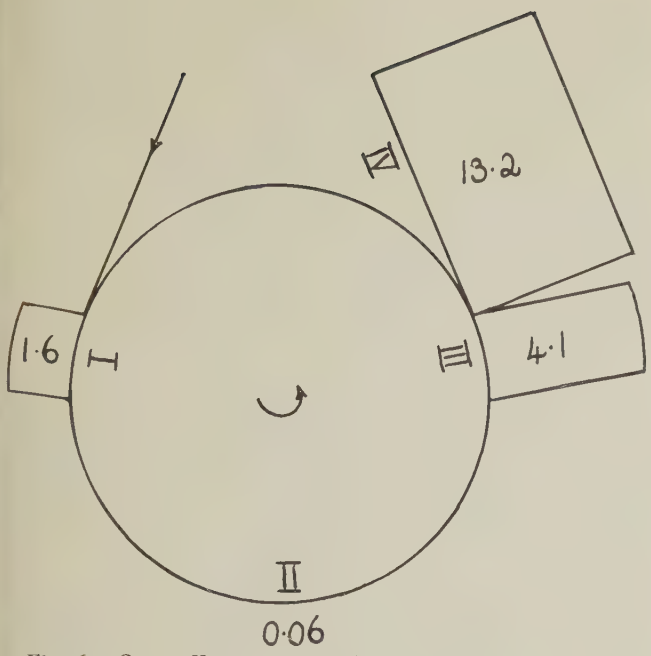


*Fig. 6. Over-all evaporation from each phase summed for the whole drying section, in $10^{-3}$ lb. per sq. ft. units*

the results calculated in the previous cycles. The absence of clearly impossible results assumes a more positive aspect of validity in such sequential calculations than in the more usual single-stage calculations encountered in engineering work.

2. The rate of evaporation of water per cycle as given in the top curve in Fig. 4 is seen to vary in a fairly complicated way. The average for the whole drying section, however, comes out at $5.4 \times 10^{-4}$ lb. per sq. ft. per cycle. As a cycle occupied 0.8568 sec. the rate of evaporation, on basis of area of paper, is 2.27 lb. per sq. ft. per hr. Montgomery (*3*) gives values of 2.1 ± 0.2 lb. per sq. ft. per hr. as characterizing "good" newsprint practice for this temperature. The agreement is again not bad.

3. It is possible that the over-all picture is correct yet it may be so far out in detail that it becomes of little practical use. It is fortunate that through the generosity of the Bowater Paper Corp. Ltd. results have been made available to check the calculations in some greater detail than would be possible purely from average results. On a machine having the conditions taken as a basis for the calculations, the following results were found:

| | *Average measurement of* p *for 1 week, lb. water per lb. moisture-free solid.* | | | | |
|---|---|---|---|---|---|
| (*1*) | *Near the front of the machine* (*2*) | *Mean value for the whole width of the sheet* (*3*) | *Ratio of mean value to that found at front of machine* (*4*) | *Calculated mean value of* p *for the whole width of the sheet* (*5*) | *From present theory* (*6*) |
| Before baby cylinder | 2.02 | 2.09 | 1.035 | (2.09) | 2.0 |
| After no. 6 cylinder | 1.65 | | (1.18) | 1.94 | 1.7 |
| 12 | 1.19 | | (1.31) | 1.56 | 1.3 |
| 18 | 0.55 | | (1.44) | 0.80 | 0.8 |
| 24 | 0.11 | | (1.61) | 0.18 | 0.3 |
| 30 | 0.04 | | (1.74) | 0.07 | 0.05 |
| 36 | 0.03 | 0.056 | 1.867 | (0.056) | 0.01 |

particularly and purposely emphasized by multiplying the rate of evaporation in phase II by 0.1. A constant coefficient of heat transfer fixed arbitrarily at the "usually met" figure of 60 B.t.u. per sq. ft. per hr. per °F. was used throughout. No account was taken of the water removed by evaporation from the bare cylinder after the sheet parts from it. The rate of evaporation, as given in equation (8), which was determined for steady conditions, has been applied where conditions are mainly characterized by being unsteady. Cross air currents have been ignored. The critical water to solid ratio was arbitrarily taken at the "reasonable value" of 0.40. Finally the equations were integrated on the assumption that $Q$ was constant, when in fact it was not. In view of these and many other simplifications used, how near are the results to reality?

While most of the assumptions made can be justified on bases of expediency or can be shown to be of minor significance, it is thought that the results are probably valid because of three reasons:

1. Viewed as a whole the results do not appear to be impossible, or even improbable. This is a subjective judgment but with results of step-wise calculations, a major fallacy in the basic equations would most probably result in *cumulative* errors of large magnitude—there were 35 cycles of four phases, each depending on

The ratio of the value of $p$ as measured for the whole width of the sheet to that found at the front of the machine is 1.04 near the wet end and 1.87 at the dry. Once again, there is no information on how this ratio varies along the machine. According to the principle that the simplest hypothesis should be adopted in absence of evidence in favor of others, this ratio is assumed to increase linearly with the number of cylinders. The values shown in parentheses in column (4) have been calculated according to this principle. Therefore, the mean value of $p$ for the whole sheet can be calculated from the value measured at the front by the simple multiplication of the figures in columns (2) and (4). These are shown in column (5). Finally in column (6) are shown the values calculated by the present system as indicated in Fig. 5. Considering that the initial value for mean $p$ was 2.0 in this inquiry compared with the initial value of 2.1 in column (5) the agreement is again not unsatisfactory.

It may be concluded that, until more accurate methods become available, the system of calculation advanced here gives values which are probably valid for the mean values obtained, averaged over a period of time long compared with the fluctuation period of the machine, and averaged for the whole width of the machine. It is probably true to state that if accurate

*measured* values of the principal parameters become available—such as the coefficient of heat transfer, the true air velocity, true values of heat transfer from and into the air by convection and radiation and true surface temperatures—then the method could form a reasonable basis for calculations and comparisons within the accuracy acceptable in engineering practice.

## DISCUSSION OF RESULTS

If the method and its results are valid, it may be useful to discuss the trends observed in some detail.

***Temperature of the Sheet*** (See Fig 3.)

The temperature difference between steam and sheet being large in the first cycle there is a large temperature increase by the end of the cycle. The resultant temperature at the end of phase III is still below 150°F., however. Consequently the cooling effect is fairly low. In the second and subsequent cycles the initial temperature differential, and consequently the temperature rise, gets successively smaller, while the final temperature of phase III, and consequently the temperature drop in phase IV, get successively greater. By the fifth cycle the two effects are equal and the sheet ends up with the same temperature at which it started. This continues to stage 10. This equality would not continue indefinitely, since the loss of water from the sheet reduces the mean specific heat, as will be seen, but, in any event, the temperature of the steam is suddenly raised in the 11 cycle and the train of events takes a new path.

The equalizing tendencies noted between cycles 1 and 5 are again seen between cycles 10 and 15. However, a new factor begins to exert an influence. The loss of water with its high specific heat reduces the mean specific heat of the sheet and consequently, since $H$ is assumed constant, the upswing in each cycle gets increasingly larger. At the same time, the higher temperatures achieved, coupled with the lower thermal capacity of the sheet, results in much larger downswings, too. The total effect is that the sheet begins each successive cycle at a *lower* temperature than the previous one, but attains a higher temperature within the cycle than before. (A casual measurement of "sheet temperature" would probably indicate increasing, constant, or decreasing temperatures with each cycle depending on what phase and what part of the phase in which the measurements are made.) This increasing amplitude of oscillation becomes so large by the 20th cycle that from then on it becomes necessary to split phase IV into two successive parts for the purposes of calculation and a single calculation becomes increasingly in error. The two triangular points shown in cycles 22 and 23 were calculated by taking the whole of phase IV as a unit, while the circular points by splitting into two parts; the error is of the order of 6°F.

By the end of cycle 23 another factor enters the picture, the value of $p$, the water to solid ratio, assumes the critical value of 0.40, and the rate of evaporation decreases with each successive cycle. The effect is to reduce the downswing of each successive cycle and the sheet assumes increasing values of temperature in all phases after the 24th cycle. As the temperature differential between steam and sheet temperatures becomes successively smaller the upswing of the curve becomes less with each cycle. Finally, the temperature curve meets another complication around the 25th cycle; the sheet reaches atmospheric boiling point of water in the middle of phase II. Will the pressure of the felt allow the sheet and the water to go to higher values, or will the sheet be limited to around 212°F.? The dotted lines indicate this uncertain region. It is fortunate that the rate of evaporation in this region is sufficiently small so that this uncertainty does not affect significantly the main conclusions regarding the water loss. In the calculations, it was assumed that the sheet remains at 212°F. as shown by the solid lines.

***The Water Content of the Sheet*** (See Fig. 4 and 5.)

The curve of water content versus cycle number descends with a variable slope but flattens at the end as shown in Fig. 5. However, for detailed analytical studies the rate of water loss for each cycle and phase shown on Fig. 4 is the more useful.

Several points are immediately noted. First, although the constant rate period of evaporation was used for two thirds of the drying section, the machine as a whole shows no such period, except over short intervals. Thus, the laboratory produced curve of a constant rate period followed by a period of a falling rate, though serving as the basic tool for the calculations, is not reflected in the results. This is because factors of temperature and specific heats complicate the picture beyond the simple lines of laboratory controlled tests.

Second, the curves for the three phases follow approximately parallel paths which are also roughly parallel to that of the curve for the whole cycle. (The quantity removed in phase II is much less than phase I and could not be plotted.) This fact means that if an improvement is effected in any phase it will be reflected in the final curve. Since the curve for phase IV contributes the major portion of the evaporation, it will be possible to simplify the discussion on how to effect an overall improvement by discussing and analyzing phase IV alone in the first place.

Third, the over-all rate of water evaporation per cycle is noticeably low for the first and last few cylinders. The low rate in the last section is due to the falling rate period of evaporation setting in. Indeed, it is believed that the curves in Fig. 4 *over*estimate the rate of evaporation in the falling rate period, because a linear law was assumed, and that the rates met in practice are lower than those calculated. The reason for this belief is seen in the fact that whilst the main body of the curve in Fig. 5 represents "observed" values as well as can be reasonably expected, its tail, beyond cycle number 30, is lower than is observed in fact, denoting that the calculations err by stating that too much, rather than too little, is evaporated here. This may be due either to taking 0.40 as the critical water content instead of, say, 0.50 or 0.60, or to assuming a linear law, or even to a fundamental error like assuming that the overall coefficient of heat transfer, which served so well in the earlier parts of drying, will still operate when the sheet is nearly dry and contact is not so good as before. All these sources of *mathematical* errors, however, have a tendency to be self-compensating: thus even if 0.80 instead of 0.40 were taken for the critical water content, the law of falling rates would have operated over a *longer* period but with a correspondingly

*smaller* drop in the rate per cycle. What is perhaps more important is that the *practical* methods available to raise the curve of water evaporation in this region are limited too. A major effect that can be achieved is by raising the temperature but the sheet is already at 212°F. midway in the second phase. Other factors will be discussed below.

The low rates achieved in the early cycles are at the full rates obtainable in the constant period. If these were raised, the production rate of the machine would be raised too. Can this be done?

The jump in the rate which occurs with the introduction of high temperature steam is obvious. Indeed, until the falling rate period arrives, there is a steady rise in the over-all rate of water evaporation per cycle with the rise in the maximum temperature of the sheet. This maximum occurs at the end of phase III, i.e., it is $t_{\Delta\theta}$. In other words, the most obvious way to increase the evaporation per cycle is to increase $t_{\Delta\theta}$. The sheet does not reach the boiling point of water until late in its drying, and therefore it may be possible to increase $t_{\Delta\theta}$ nearer the boiling point of water in the earlier cycles. There may be, indeed there *are* many papermaking reasons why the temperature of the sheet must *not* be pushed too high too early, but assuming that the temperature could be pushed up without detriment to the paper, how is it to be done?

Equation (3) shows $t_{\Delta\theta}$ as a function of the other factors involved, namely $t_c$, $t_o$, $H$, $M'$, and $\Delta\theta$. Of these $t_o$ and $M'$ are fixed by conditions of the paper. Thus, $t_{\Delta\theta}$ can be raised by a rise in $t_c$, $H$ or $\Delta\theta$. The effect of raising $t_{\Delta\theta}$ by using higher steam pressure can be seen from equation (25).

$$\frac{dt_{\Delta\theta}}{dt_c} = 1 - \exp\left(-\frac{H}{M'}\,\Delta\theta\right) \qquad (25)$$

Thus, the increase in $t_{\Delta\theta}$ is not strictly linear with $t_c$ but depends somewhat on $H$ and $M'$ and is highest when $H$ is high and $M'$ is low. This means that the relative increase in $t_{\Delta\theta}$ due to an increase in steam pressure will be greater near the dry rather than the wet end of the machine. The practical papermaker is governed by many other factors than simply the sheet temperature in his decision as to what steam pressure to use, but clearly the use of the maximum in steam pressure that mill economics and papermaking considerations will allow is suggested by equation (25) since the equation shows no mathematical maximum in $t_{\Delta\theta}$ with $t_c$.

The maximum sheet temperature is also increased by an increase in $H$, although the relative increase is *less* the higher $H$ is, as can be seen from equation (26).

$$\frac{dt_{\Delta\theta}}{dH} = (t_c - t_0)\,\frac{\Delta\theta}{M'}\exp\left(-\frac{\Delta\theta}{M'}H\right) \qquad (26)$$

In the calculations $H$ was taken as 60 B.t.u. per sq. ft. per hr. per °F., but in fact the effective $H$ was actually higher. This is because in phases I, II, and III an average of some $10^{-4}$ lb. of water was being evaporated in some 0.64 sec. from each square foot of paper. This requires about 560 B.t.u. per hr. heat input. As the average temperature of the sheet is some 50°F. below that of the steam this corresponds to about 11 B.t.u. per sq. ft. per hr. per °F. Thus, the effective value of $H$ was, on average, 71 B.t.u. per sq. ft. per hr. per °F. An upper limit for $H$ may be taken to be that obtaining when water is heated as a stationary film on a steam heated cylinder and while figures differ, the value is well above 200. Thus, there appears to be some scope in improvement in papermaking evaporation rates, where average values for $H$ of 60 are considered fairly good, by raising $H$. Yet it is not as easy to do this as to state the desire or even the necessity for it. Probably the chief stumbling blocks are film resistance inside the cylinders, air film and scale resistance on the outside, and the necessity to limit the felt pressure by other than drying considerations.

To increase $t_{\Delta\theta}$ by increasing $\Delta\theta$, i.e. by increasing the angle of wrap around the cylinder and the diameter of the cylinder, may be the next consideration. Equation (27) shows that the law of diminishing returns sets a limit *in practice* to both methods as the relative increase in $t_{\Delta\theta}$ gets smaller the higher $\Delta\theta$ becomes.

$$\frac{dt_{\Delta\theta}}{d\theta} = (t_c - t_o)\,\frac{H}{M'}\exp\left(-\frac{H}{M'}\,\Delta\theta\right) \qquad (27)$$

Again, economics and engineering considerations other than heat transfer govern the choice of a value of $\Delta\theta$.

It was stated that the "most obvious" way of increasing the rate of evaporation was by means of an increase in $t_{\Delta\theta}$. Are there other ways?

The influence of $t_{\Delta\theta}$ on the over-all rate of evaporation per cycle is through its influence on $P_w$ in equation (8). Thus, having achieved the highest value for $P_w$ in this equation the rate of evaporation can still be increased by changing the other factors involved. It will be seen that these other factors are of somewhat less promise compared with $P_w$ which rises steeply with temperature. Thus the rate of evaporation rises (1) as the 0.77th power of the length of phase IV, (2) as the 0.85th power of the relative speed between air and sheet, (3) as $P_a$, the partial pressure of the water in the air, *decreases*.

Trial calculations will show that each succeeding foot in phase IV contributes less to the evaporation—not only because $(dw/d\theta)$ increases as $L^{0.77}$, but because the average temperature in each succeeding foot and hence $P_w$ is less—so that it is doubtful whether phase IV should be increased beyond, say, 4 ft. on multicylinder driers. Similarly calculations will show that unless the air is totally recirculated, $P_a$ is usually very small compared with $P_w$ and can be considered as of secondary importance. ($P_a$ may be very important from other points of view, e.g., ceiling condensation and exhaust hood corrosion, but that is outside the scope of this paper.) Thus, the major remaining factor is relative velocity of the sheet to the air.

Here it should be noted that $V$ should be increased by blowing air relative to the sheet and *not* by an increase in the sheet speed. This is because while the *rate* of water evaporation increases as the 0.85th power of the sheet (or machine) speed, the time of dwell of the sheet in the evaporating zone *decreases* with the first power of speed, so that the over-all effect of increasing machine speed is a slight *decrease* in the amount evaporated per phase or cycle. Since air blowing has to be done at the expense of mill power supply, an economic balance will have to be struck in deciding how much air can be blown against the sheet before the consumption in power exceeds the benefit in drying. It is suggested that the use of calculations such as those employed in

this inquiry, coupled with adequate measurements will produce a reasonable balance after a few trials. (Blowing air *across* the machine to improve the *uniformity* of drying is another matter.)

In this discussion of possible ways of improving the rate of water removal per *cycle*, it must have been evident that, while the sheet spends 60% of its drying time in phase II, the over-all rate of water loss per cycle taking place in this phase is negligible. This subject was left to be discussed last because of its special interest.

### THE INFLUENCE OF THE FELT

The calculations were made on the basis that no special phenomenon other than restricted evaporation took place in phase II. The intention was to calculate the amount evaporated according to established principles and if these added up to less than the total observed, to attempt an explanation for the observed difference on the basis of water removal by other means, i.e., water evaporation from the bare cylinder surface after the sheet leaves it and water abstraction by the felt. As it turned out, the calculations account for the *whole* of the water lost. Indeed, they account for a little more than the whole observed, if significance is accorded to the small difference appearing between the water content of the sheet as calculated and as observed after the sixth and twelfth cylinders; but it is believed that the difference is within the experimental and calculational errors. Thus, it may be concluded that for machines running at this speed on news and magazine paper, the water evaporation follows known principles and occurs mostly in phases I, III, and IV.

This conclusion would not be *per se* of any special significance to the use of felts. Felts would still be justifiable as the real contributors to the high over-all coefficient of heat transfer necessary for a high average temperature and high evaporation rate in phases III and IV. Thus, the felts would still be among the prime causes and influential factors in multicylinder drying of thin sheets which are unable to exert pressures on the cylinder under their own tension. What gives this conclusion significance is that it conflicts with previously reported *observed* facts. Sherwood (*4*) *et al.* and later Smith and Attwood (*5*) have made careful measurements on similar systems to the one under study and concluded that from 60 to 80% of the observed water removed was abstracted while the sheet was covered by the felt. Since there is no apparent reason to doubt the validity of these observations, it follows that a system of calculations which is in conflict with them must either be itself invalid or must be dealing with conditions to which the previous observations do not apply. The validity of the calculations was discussed in the section Validity of the Analysis and it was seen that, on the whole, the predictions according to the theory accorded with the few results available from observations within the experimental errors of the observations. Thus, until positive proof is adduced against the present analytical methods, it is probably not unreasonable to accept the second of the two alternatives, i.e., in machines of the type under discussion the amount of water leaving the sheet in phase II when the sheet is covered by the felt is negligible in comparison with that evaporated when the sheet has at least one side exposed to the atmosphere.

This last conclusion immediately raises three specific questions:

1. What is the cause of the difference of the action of the felt as reported by previous experimental observations and the present theoretical analysis?
2. If the cause for the difference is ascertainable is it desirable to remove it or to maintain it?
3. If it is desirable to remove this cause, how is this to be done?

It may be useful to resolve these questions in turn.

To ascertain the cause for the difference involves an understanding of the mechanism of water removal in phase II. In a paper on "The Functions of the Felt in Water Removal on the Papermaking Machine" given to The Symposium on The Fundamentals of the Paper Machine at Appleton, Wis., September, 1954, organized under the auspices of TAPPI and CPPA, Nissan (*6*) argues that the felts in Smith and Attwood's experiments removed the water in *the liquid state* and gives evidence, abstracted from the experimental results themselves, in support of this argument. Indeed, even without detailed argument it is difficult to see how four times as much water would *evaporate* into the felt as into the free air surrounding the sheet in phases I, III, and IV in the earlier cycles where Smith and Attwood report the maximum felt influence. Accepting the hypothesis of the removal of the water in the liquid state, then it must be concluded that in the machine under discussion the felt could not have been in a state conducive to liquid absorption. This is understandable since the speed of the machines in both Sherwood's and Smith and Attwood's experiments were low compared with the speed of the newsprint machine being studied. Thus, it appears that in medium and high-speed machines the felt, as at present made and used, probably does not remove water by absorption and subsequent evaporation as it appears to do on slow machines.

Secondly, it can only be desirable to remove the cause of the difference between the behavior of the felt on high and low-speed machines if, by doing so, some advantage is obtained. If felts on high-speed machines could be induced to absorb water they would still require heat to evaporate the water from the felt. Therefore advantages could accrue only if either or both of the following possibilities were achieved: (1) With the liquid absorption mechanism operating the productivity of the machine would be enhanced as higher speeds could be used. (2) With some of the water removed from the sheet as liquid, low grade heat, from flue gases, say, can be utilized to evaporate the water from the felt by blowing air first heated from such a source, through or over the felt in a manner which is not possible with the delicate sheet of wet paper itself. This would effect not only an increase in the rate of production, but also a saving in the cost of drying.

Thus, no general statement can be made and it must be left to the local engineer to study the gains effected and balance them against the increase in capital and running costs before a decision can be made whether in a particular machine, the liquid absorption mechanism should be encouraged or ignored.

Finally, supposing an analysis shows that in a particular machine it is desirable to encourage the liquid absorption of the water by the felt with subsequent

evaporation, how can this be done? Some indication has already been made of possible methods. The principle is to return the felt to the first cylinder in as dry a state as possible and to try and maintain it dry between cylinders in, say, the first 10 cycles. Increasing the number of felt drying cylinders—where space does not allow the installation of more driers, even robbing the sheet of one or two driers in the first ten to dry the felts—may produce an increase in the amount of water lost in the first 10 cycles out of proportion to the extra heating area. Blowing air through or over the felt, either on its return journey or between cylinders, would similarly help this mechanism. Essentially, however, these steps would not be of optimum effect unless the felt itself is designed with the liquid absorption mechanism being fully in mind.

On the basis of this argument the felt covering, say, the first 10 cylinders, should be different in characteristics from those covering the later cylinders. Essentially the felt covering the first 10 cylinders should combine the functions of a wet felt on one surface with that of a dry felt through the rest of the structure. Thus, a two-structure felt is necessary. The surface next to the sheet should be woolen, soft, bulky, close-textured, and with a good nap; the rest of the felt and the surface away from the sheet should be open-textured and permeable but should provide the mechanical strength required. In this way the felt will act as a hot-press felt on one side and as a freely evaporating dry felt on the other.

## CONCLUSIONS

Although an attempt to extract some practical conclusions and recommendations was made in this paper, the main purpose was and remains to provide a means whereby the behavior of the sheet on the paper machine may be a little better understood than before. A subsidiary purpose was to indicate the type and grade of information required from measurements in the laboratory and on the machine if any precise calculations of drying section characteristics are to be made for the purposes of design or operation. It is hoped that the paper goes a little way to achieve these two purposes.

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The paper gains immeasurably through the generous permission of the Bowaters Paper Corp., Ltd. to use the results obtained some years ago on one of their machines while one of the authors (A.H.N.) was in their employ. To them and particularly to their technical director, George F. Underhay, are due the authors' thanks.


## DISCUSSION

A. E. Montgomery: The paper by Nissan and Kaye impresses me as a notable attempt to analyze mathematically the complex mechanism of drying on a multicylinder paper machine using drier felts, but it leaves me fearfully unsatisfied with the conclusions drawn from the mathematical analysis.

At first I had hoped I might use their own formulas and data, and by making other reasonable but different assumptions from those used by the authors, find out whether their conclusions remained valid; but lacking information on the exact manner in which they made their detailed calculations, I fear that my rusty mathematics would likely only confuse matters. I do wonder, however, if I might have the temerity to suggest to the authors that they make the different assumptions I want to suggest, recalculate on this basis, and thus determine whether their mathematical treatment still points to the same conclusions.

My greatest objection is to the assumption first discussed under "Fifthly," where it is determined that the felt will be assumed to take no active part in water removal, and it is assumed (for lack of any real knowledge) that the rate in phase II is one-tenth that in phase IV. This seems so contrary to my preconceptions and experience that I must be doubtful until additional calculations are made with the assumption of a higher value. Then if the new computations do lead to results differing widely from actuality I would be forced to revise my earlier ideas. If the results are not widely different, the conclusions reached by this paper are invalid and misleading.

Further, I would like to suggest to the authors that, for their own edification, they take an imaginary machine the same as the subject one, but having only one-third as many driers. It would be running on the same grade of paper, with the same steam pressure, but would be running only one-third the speed. (Actually, experience indicates the speed would likely be somewhat over one-third, but that is immaterial.) If the same method of calculation is followed as on the subject machine, making the same assumptions as to the ratio of drying in phase II, over-all heat conductance, etc., I suspect it will be found that the temperature changes in the sheet during each cycle will be calculated to be impossibly high, thus invalidating the assumptions. I suspect that only by assuming a considerable water removal in phase II will they arrive at reasonable calculated sheet temperatures for such a machine with only a few driers. If it is true for the hypothetical machine it must also be true for the longer one. Perhaps I am wrong in this, but I believe the authors should, and will wish to, satisfy themselves on this score.

I am not sure whether it will make any substantial difference in the results, but I do further believe the assumed over-all coefficient of heat transfer of 60 is too high. If the steam consumption on the subject machine is known, it is a simple matter to calculate with reasonable accuracy just what it actually is. I suspect 45 is much closer to actuality. In fact, I figure that if, on this machine, the over-all coefficient is 60, then the steam consumption is something like 1.95 lb. per lb. of water evaporated, and that seems most unreasonably high. I append my calculations on this.

Obviously the authors are correct in mentioning the

fundamental error in assuming the over-all coefficient of heat transfer to be uniform throughout the machine. On the last 20 to 25% of the driers it must be much lower due to the decreased conductivity from drier shell to paper, which is the dominant factor in the over-all conductivity. Yet I doubt that this error does more than change slightly the curve for the calculated moisture and temperature of the sheet through the cycles.

All of this points up to the exceedingly difficult problem which the authors faced so courageously and energetically. This paper, at the very least, presents a new tool for future work on the problem of drying, and even if we shall find that the tool needs some reshaping here and there, it surely will have served to extend the frontiers of our knowledge.

*Appended Calculations*

$$S/W = 0.0218\,(1 \times 36 + 36 \times 60)$$
$$= 0.0218 \times 2196 = 47.8 \text{ sq. ft. per in. width}$$
$$R_P = \frac{-912 \times 28.7}{47.8 \times 600} = 0.91 \text{ lb. paper per hr. per sq. ft. (av.)}$$

Pounds paper/hr./in. width, $47.8 \times 0.91 = 43.5$.

If $U = 60$ B.t.u. per hr. per sq. ft. per °F. diff., and if $\Delta T = 228 - 175$ (from Fig. 3) $= 53$°F., total heat transmitted per inch width would be $60 \times 47.8 \times 53 = 152{,}000$ B.t.u. per hr.

For average of 5 p.s.i. steam condensed, heat given up is the latent heat of 960 B.t.u. per lb.

Hence steam condensed would be $152{,}000/960 = 158.5$ lb. per hr. per in. width.

This would be $158.5/43.5 = 3.64$ lb. per lb. paper.

Say sheet dried to 6% final moisture. Pounds water evaporated per pound paper as dried is $94/32.8 - 1 = 1.87$.

Pounds steam per pound water evaporated is $3.64/1.87 = 1.95$, which is high.

A. H. Nissan: I am in complete agreement and sympathy with your reviewer about the points which have been troubling him. Indeed, the whole purpose of the paper was to stress the surprising nature of the results in view of "the preconceptions and experience" which your reviewer and I share about the functions of the felt. Your reviewer has put his finger directly on the main difficulties which have exercised both Mr. Kaye's and my mind for a considerable time. Indeed, we two who have gone intimately into the detailed calculations have come across other features of difficulty and doubt—in addition to those which are troubling your reviewer. We tried to indicate these in the paper and I made it my business at the three lectures I gave in the States on this paper to stress these doubts to the audience. Having said all this I am, unfortunately, not in complete agreement that the methods suggested by your reviewer will, in fact, be unequivocal enough or sufficiently critical in nature as to resolve these difficulties and enable us to pronounce on the validity of the conclusions.

All the same, if the calculations he suggests were not as complex and lengthy as they are, I would have gladly done them, even though I believed they were unproductive. A machine with 35 cylinders implies 140 phases and as some of them have to be split into two or three subsections, a calculation for each machine implies some 180 steps approximately. Since the calculations are sequential, a mistake in any one step affects all subsequent ones; thus Mr. Kaye and I have adopted the policy of calculating all results at least twice with some spot tests involving three calculations. Thus, a calculation for a machine involves all in all some 400 to 450 separate calculations. With each step taking between 15 to 20 min. to calculate, record, plot, and scrutinize, you will see this means some 100 to 150 solid hours of arithmetic at the least.

As I mentioned, we would gladly do this if we believed it served any purpose. In the appended memorandum I give detailed reasons why I do not think it does. Here I may briefly state the position as follows: every student knows that to solve a problem mathematically one must have as many equations as there are unknowns. Thus, if we wanted to determine three unknowns we must have three independent equations. Should we have only two equations, the only method available is to *guess* at one of the unknowns and estimate the other two on the assumption that our guess was right. Now, if we do that, there is simply no way of proving that our guess was right. If the results agree with our preconceptions, we tentatively accept the guess to be right; if they don't, we think the guess was wrong. The important and crucial point is that no amount of recalculation or refinement can overcome this difficulty. The only way in the absence of a third relationship between the unknowns is to *measure one of them.*

Thus, in our case, what is missing is a measurement of certain important parameters. We knew that we were so handicapped when we began our calculations. However, we wrote and presented the paper with the threefold purpose of indicating to the people in the industry (1) the data required to achieve an accurate solution of this difficult problem; (2) that if the measurements were made, physical and mathematical principles could be formulated to solve the problem; and (3) to indicate the probable nature of the solution.

***Memorandum on Reviewer's Comments***

If I may, I shall take the points raised by your reviewer individually. He raises three:

1. *The Function of the Felt.* As we stress in the paper—indeed it was our sole original intention—the method adopted in the paper was to calculate the total water loss by ordinary processes of evaporation for phases I, III, and IV, and to subtract this value from the total observed so that the amount lost through or into the felt could be estimated. In order to do this we had perforce to assume that the felt did not remove water itself. What surprised us and your reviewer so greatly was that we found that the amount calculated equaled the amount observed, leaving none for the felt. Your reviewer suggests that we should now recalculate on the basis that some of the water is removed through or by the felt. Such a calculation is only possible under one of two systems: either the water evaporates into the felt or it is absorbed as a liquid to be evaporated later. Let us consider the two systems:

(a) *Evaporation.* We have to assume here that the water is evaporated into the felt. If this assumption is valid, then our method of calculating the temperature rise in phase II cannot be used in its present simple way as equation (2) does not take account of the latent heat of evaporation. We have already derived the type of equation that would have to be used in its place if evaporation of water accompanied the rise in temperature in phase II and we find that instead of equation (3) a complex function results which can only be

integrated graphically or numerically. For a machine with 35 cylinders such calculations will take a great deal of time unless electronic computers can be utilized. This amount of work would only be justifiable if, in fact, the results achieved were of crucial value. As can be shown in a simple way, this is not a possibility. Thus, the temperature rise in phase II is a maximum for any given quantity of heat transmitted from steam to paper if, in fact, all of it goes into sensible heat. Any supposition that the water is evaporating at the same time as it is heating up will either imply that a greater amount of heat is being transmitted than we have assumed or that the final temperature in phase II is lower than the one we have already calculated by the present method. Your reviewer has already given the opinion that the assumed over-all coefficient of heat transfer of 60 is too high. Consequently, if we keep the rate of heat transfer at 60 or lower, the temperature level at the end of phase II must be on average less than we have calculated. Now from Fig. 3 it is seen that nowhere in the first 15 cylinders—where the influence of the felt is usually considered to be highest in removing water—does the temperature reach boiling point of water. Consequently the amount evaporated into the felt by ordinary laws of evaporation into a saturated system must inevitably come out to be small. Now from Fig. 6 it will be seen that even if the amount evaporated in phase II were ten times what we calculated, that is the felt exerted no more resistance than an open space of still air, it would still be negligible. The important point to realize here is that when we talk of the felt having a profound effect it is normally meant that the felt removes two or three times as much water as is evaporated in the air spaces. In other words, we will require a rate of evaporation of the order of 500 times the rate we calculated. I know of no principle to which I can appeal in physics and from which I could get such terrifically high rates for the system envisaged. Thus we are forced, if we are going to calculate again on a basis which allows more water to be lost through or by the felt, to assume that the water is, in fact, removed as liquid and not as vapor.

(b) *Liquid Removal.* Once again to calculate accurately the removal of water from the sheet in the liquid state by the felt one must have some principle in physics to use for quantitative evaluation. I have indicated in another paper, which I gave at The Institute of Paper Chemistry last Summer and published in *Tappi* for December, 1954, a very tentative and crude approach to that problem, but I have no exact method. Fortunately, however, one can use an approximate approach as follows.

"Preconceptions and experience" to which your reviewer referred and which I share with him, usually allow something like two or three times the amount of water lost in the air spaces of the first, say, 12 cylinders to be removed through or by the felt. Now our calculations give the amount evaporated in the air spaces with negligible contribution from the felt. Let us, therefore, take this amount and assume that twice as much has been removed by the felt. We get the following table.

| *Cylinder no.* | *Water to solid ratio as calculated at present* | *Water removed in air spaces* | *Water assumed to be removed by felt = 2 previous columns* | *Total water removed by new calculations* | *Water to solid ratio by new calculations* | *"Actual" water to solid ratio* |
|---|---|---|---|---|---|---|
| Before baby cyl. | 2.0 | .. | .. | .. | 2.0 | 2.0 |
| After | | | | | | |
| No. 6 cyl. | 1.7 | 0.3 | 0.6 | 0.9 | 1.1 | 1.94 |
| No. 12 cyl. | 1.3 | 0.7 | 1.4 | 2.1 | 0.0 | 1.56 |
| No. 18 cyl. | 0.8 | 1.2 | 2.4 | .. | 0.0 | 0.80 |
| No. 24 cyl. | 0.3 | 1.7 | .. | .. | 0.0 | 0.18 |
| No. 30 cyl. | 0.05 | 1.95 | .. | .. | 0.0 | 0.07 |
| No. 36 cyl. | 0.01 | 1.99 | .. | .. | 0.0 | 0.056 |

A study of this table will reveal that the further calculations suggested are not decisive in validating or refuting the theory. Thus, it will be seen that according to the table the sheet would be completely dry by the 12th cylinder. In the words of your reviewer, "the new computations do lead to results differing widely from actuality." The reviewer stated that in such an event the new calculation should force him to revise his earlier ideas. This is where I have the temerity to disagree with him. I think that these calculations do not, in fact, necessarily prove that our system of calculations as at present constituted is any more justified than we had right to assume they were before the new calculations were made. I say this against our own theories because this new calculation is still made on the basis of our theories regarding the form each function takes; they neither add to nor subtract anything from the basic equations. In other words, despite these criteria which your reviewer kindly put forward to prove our theory, and despite the temptation to extract confirmation from them, I am not personally satisfied that, in fact, the theory we put forward has received any *further support* from them since we have not, in these calculations, critically checked the detailed steps and the detailed assumptions made in the theory.

Suppose now that the table in fact gave a different result. Let us say that we so adjusted, *arbitrarily*, our functions that we made one third of the total water loss go into the air and two thirds into the felt. Would that have affected our conclusions? We would have concluded that the felt removes water by liquid absorption—in an arbitrary, unspecified manner—and that the felt deserves further attention. But this conclusion is, in fact, our present one; there is no change.

It will be seen, therefore, unless we get *new data* to check our calculations with more certainty than is available to us at present, no amount of internal adjustment can give us the desired decisiveness. What is wanted is precise measurement of the parameters which go into our equations and not further manipula-

tion of the equations to yield acceptable results. This point arises again from the reviewer's second suggestion.

2. *Using One-Third Speed with One-Third as Many Driers.* Once again the calculations suggested by your reviewer will be, naturally, long, but fortunately we can circumvent them by approximations. Thus: for one third the speed we require one third the quantity of water to be removed, but since the dwell of the sheet in the drier is for one third of the time, the over-all rate of water removal in pounds per square foot per hour remains constant. By cutting the speed to one third, the over-all rate of evaporation according to equation (8) is cut down to 0.85th power of one third. This means that due to the loss of speed the evaporative rate will be of the order of 0.4 the original rate if the temperature conditions were the same. Thus, to bring the rate of evaporation to the original the temperature rise should be such as to produce $2^1/_2$ times the rate. In other words, the average temperature of the sheet will have to be about 30°F. higher than before, *if all other conditions were the same.* But other conditions are, by the posing of the problem itself, *not* the same. It is precisely at lower speeds that the importance of the felt becomes of paramount importance in removing water in the early stages of drying as I have tried to show in my paper on the functions of the felt which I gave to *Tappi*, where I have shown that at slower speeds and higher temperature rise per cylinder the felt appears to remove water by liquid absorption. Thus, running at one third the speed and with one third the number of cylinders the average temperature will be *less* than 30°F. higher than in the machine under study. If the water removed by the felt is appreciable, as we have reason to believe to be the case with a slow machine, then an average rise of 10 to 15°F. is all that is necessary. In other words, the more exact calculations will, once again, lead us to uncertainties which do not resolve the question whether the present theory is 100% accurate or not, since they do not crucially affect our conclusions.

3. *The Over-all Coefficient of Heat Transfer.* We agree with your reviewer that the figure of 60 which we assumed may appear a little on the high side. On the other hand, I think that your reviewer's figure of 45 is much too low *for our calculations* although it is of the right order as this figure is conventionally calculated and reported. While I do not know exactly how your reviewer estimated this figure, since I have not seen his calculations, I think that he probably calculated it on the basis of total drier surface. We, of course, require the figure per unit area of actual contact and this is, naturally, higher. To compute an exact figure one should have the mean temperature difference between steam and paper and this, unhappily, was only available to us *after* we completed our calculations. Now that we have this figure, from our first approximation it appears that a more exact figure, were we to get a second approximation on the basis of the first, is probably not far off 50 to 55. Once again, I do not feel that the great amount of calculations required to rederive the figures submitted for publication will give us any greatly different picture from the present one, and since the new figures will be no more definitive than the present ones I am inclined to think that the effort will not be justified by the results. Only measurements of this figure will prove useful ultimately.

You will see from all this that, in my opinion, such recalculations and attempts at refinement will not produce worth-while results. This is because in all such attempts we will have to use, once again, guesses about important fundamental parameters in the equations. If I may repeat myself, what is required is not recalculations but measurements of the parameters shown by this theory to be necessary. If such measurements could be done, then recalculations using the measured parameters, instead of the present approximations, will reveal the difficulties in the theory which can then be remedied. The whole purpose of this paper, in my view, is to indicate the type of factors required, to encourage someone with a practical machine and the interest and ability to measure these factors, and to check the theory against practice. I have no doubt in my mind that the present theory will be found to be too approximate and too crude a tool, but then the paper will have served its purpose in inducing or encouraging others to shape more precise and sharper tools. It was these thoughts that prompted us to entitle the paper "An Analytical *Approach*. . ." It can only become "An Analytical *Method*. . ." when further data become available.

A. E. Montgomery: The letter from Mr. Nissan and the attached memorandum from him throw much more light on his thinking with regard to his mathematical approach to the study of paper drying. When I wrote on January 5, I did not realize the laboriousness involved in the calculations I suggested, and only hoped that a recalculation on the shorter machine would quickly disclose whether or not our assumption is warranted that little water leaves the sheet in phase II.

Personally, I remain doubtful of the validity of his conclusion that the amount is small on the machine he studied. Mr. Nissan agrees that on a machine having only a few driers the water removed by the felt must be considerable. My belief is that the proportion is about the same whether or not there are many or few driers, which is to say, in other words, whether it is a slow or a fast machine.

Incidentally, in his memorandum under subject 2, I cannot understand his statement that "the dwell of the sheet in the drier is for one third of the time,. . . ." The total time of the sheet in the drying section of the paper machine is, of course, the same regardless of the length of the machine, and if the driers are the same in diameter, the duration on each individual drier is three times as great with one third the number of driers.

In my comment regarding the over-all coefficient of heat transfer, I did suppose the base for the calculations was total drier surface. I stand corrected, and a coefficient of 60 would not be too high on the basis of area of actual contact. As Mr. Nissan says, the calculation for actual practice becomes highly complicated, for heat is flowing from steam to drier shell, and through the drier shell, at constant rate over the *entire* area covered by the width of the sheet, but into the paper only for the area of actual contact.

I agree with Mr. Nissan in his hope that this commendable effort may induce others to advance further along this mathematical approach.

# Chemical and Heat Recovery with the Venturi Scrubber at Thilmany

P. H. WEST

**In 1946 a pilot plant venturi scrubber, using water to clean the recovery furnace flue gases, was tested at Thilmany; it showed chemical recovery efficiencies of about 90%. A similar full-scale unit, installed in 1947 following the then existing 120-ton recovery unit, substantiated these findings. Further pilot studies, employing concentrated black liquor instead of water, indicated improvement in heat recovery efficiency over that of conventional kraft recovery systems, while maintaining a high degree of chemical recovery. By mid-1951, because of greatly increased pulp production and the demand for 600 p.s.i. steam, Thilmany purchased a new 250-ton B&W recovery unit equipped with a black liquor venturi scrubber. The decision to include the venturi as an integral part of the unit was based on several years of highly satisfactory performance from the water scrubber, the black liquor pilot unit, and such other considerations as capital investment, space requirements, operation, and chemical and heat recovery. This entire unit, in operation since May, 1953, shows chemical collection efficiencies of approximately 90%, and heat recovery greater than normal.**

PRESENT-day kraft and soda pulp mills achieve a high degree of efficiency in recovery of heat and entrained chemical from the flue gases produced by the burning of waste or black liquor. In addition to normal boiler heat traps, consisting of boiler, economizer, and air heater surface, direct contact evaporators, such as cyclones or cascades, are generally used to improve the system thermal efficiency. Fume or dust collection is accomplished by means of electrostatic precipitators in the majority of mills. However, such equipment does not attain the economical end point with regard to either heat or chemical recovery. Investigators at Thilmany, along with many others in the industry, have felt for some time that wet scrubbing of recovery unit flue gases offers the best possibility for improved recovery, not only of soda, but also of sulphur and heat.

## WATER VENTURI SCRUBBER

Consequently, late in 1945, after consultation with two authorities in the field of scrubbing, A. W. Anthony, Jr., president of the Pease-Anthony Equipment Co., and H. F. Johnstone, professor of chemical engineering at the University of Illinois, it was decided to make a test installation of a conventional Pease-Anthony cyclonic-spray tower to handle approximately 7% of the gases from the recovery unit. Investigation with this pilot plant continued through 1946 and led to the development of the venturi atomizer which, in combination with a dry cyclone separator, ultimately became recognized as the venturi scrubber. A summary of these studies and the historical background of the venturi scrubber were reported by Collins, Seaborne, and Anthony (*1*), and Collins (*2*). During the pilot-plant period of investigation, water or a circulated brine solution was used as the scrubbing medium, and saltcake recovery efficiencies averaged about 90%.

Having attained these highly satisfactory results with the pilot plant, the next logical step was to install a full-size unit to handle all of the gases from the recovery unit. Early in 1947, Thilmany in cooperation with the Babcock and Wilcox Co. initiated the design, fabrication, and installation of a full-scale venturi scrubber to use a water solution of the collected saltcake as the scrubbing medium. This apparatus was placed in service in July, 1947, and its operation soon confirmed the pilot-plant results by recovering approximately 90% of the saltcake in the gases leaving the recovery unit. Thilmany's experience with the full-scale water venturi scrubber is described by Collins, Seaborne, and Anthony (*3*), and Collins and West (*4*). By controlling the makeup and bleed-off rates in the saltcake brine recirculating system, the concentration was maintained at about 30% solids. Incidental to the fume collection, the flue gas temperature was cooled, by useless evaporation of water, from 300°F. to about 165°F.

## PILOT BLACK LIQUOR VENTURI SCRUBBER

Although chemical recovery with this water or brine scrubbing was very satisfactory, no useful cooling of the flue gas was done. In fact, the thermal efficiency of the system was slightly reduced by the addition of the water solution of the recovered dust to the black liquor. Consequently, the use of black liquor from the multiple effect evaporators for scrubbing the flue gases was indicated as the next logical step in attempting to improve the over-all heat efficiency of the system. Late in 1947, the original pilot plant was again set up, this time using concentrated black liquor for scrubbing a portion of the gases leaving the recovery unit. The subsequent test work by Thilmany and B&W indicated that with this arrangement, saltcake recovery of approximately 90% could be maintained, while at the same time the concentration of the black liquor could be increased from about 45 to 65%, as a result of dropping the exit flue gas temperature to about 170°F. Pilot work was then terminated, but because rather extensive modifications to the existing full-scale water scrubbing venturi scrubber were required to convert it to a liquor scrubbing unit, such conversion was decided against at that time.

## THILMANY'S 1951 RECOVERY PROBLEM AND ITS SOLUTION

By mid-1951 the daily pulp production had increased

P. H. WEST, Pulp Mill Superintendent, Thilmany Pulp & Paper Co., Kaukauna, Wis.

to about 165 tons which, because of Thilmany's high black liquor solids per ton (approximately 10% more than the normal 3000 lb.), meant that solids equivalent to over 180 tons of production were being returned to the recovery system daily. Although the 120-ton B&W recovery boiler installed in 1942 was able to incinerate and smelt chemical from most of the liquor returned from this greater tonnage, its total steam production did not increase. Thus, on a tonnage basis, the boiler was generating only about 6500 lb. of steam per ton of pulp, and at only 200 p.s.i.

Despite about 90% recovery of the soda in the stack gases by the water venturi scrubber, saltcake makeup was gradually increasing, due principally to the increased black liquor sewer losses resulting from lack of capacity to process all of the black liquor returned to the recovery system.

The five-body multiple effect long tube evaporator also was taxed severely to concentrate to 50% solids the black liquor from 165 tons of pulp daily. It was necessary to maintain this concentration in order to have 62% solids liquor coming from the two disk evaporators for firing the 120-ton recovery boiler.

Finally, because adequate capacity was then available for producing 200 tons of pulp per day, except in the recovery, it was economically imperative that that department be given 200-ton equipment. Furthermore, additional 600 p.s.i. steam was needed to drive two new turbines.

It is a generally accepted fact that for the most economical operation of a kraft pulp mill a recovery unit is required which (1) recovers, for re-use in the process, the highest practical amount of chemical from the gases produced by burning black liquor, and (2) reduces the temperature of those gases to recover a maximum of sensible heat from them. Equipment for these purposes should have an availability as near 100% as possible and should require little or no operating attention.

After a comprehensive study of the entire recovery problem, including liquor evaporation as well as heat and chemical recovery, the decision was reached to purchase a 250-ton, 600-p.s.i., B&W recovery unit equipped with a black liquor venturi scrubber. While it was planned to operate the furnace at about the 200-ton rate, the larger unit was selected (1) because Thilmany's black liquor solids are about 10% more than

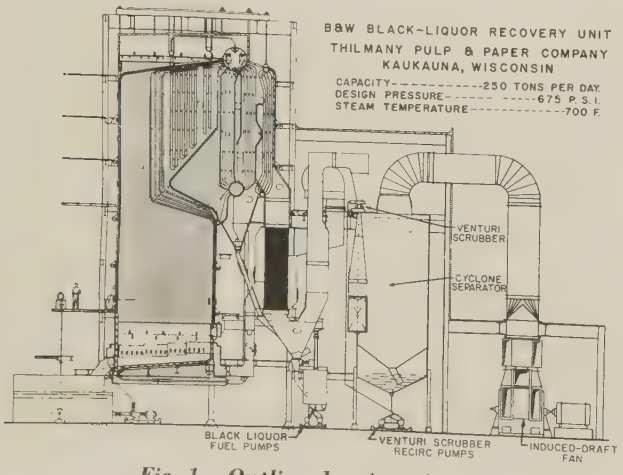


*Fig. 1. Outline drawing of unit*

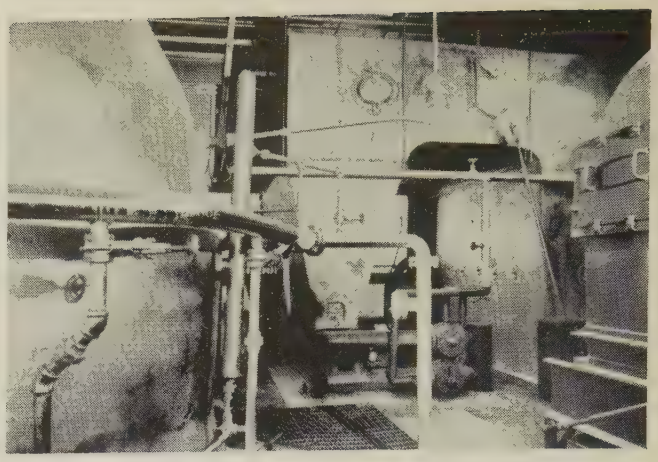

*Fig. 2. Venturi throat and top of separator*

the usual design figure of 3000 lb. per ton of pulp, and (2) because of management's desire to provide for some possible future expansion. (The wisdom of this foresight was evidenced in the first year's operation when pulp production increased to 225 tons per day and the amply sized recovery unit generated an average of 11,000 lb. of steam per ton of pulp.)

Careful consideration was given to the following factors which influenced the decision to include the venturi scrubber as an integral part of the recovery unit:

1. *Capital Investment.* Because it combines in a single piece of equipment both fume recovery and direct evaporating functions, the scrubber, which consists essentially of the venturi atomizer, cyclone separator and auxiliaries, represents a relatively low capital investment.

2. *Minimum Space Requirements.* Due to its simplicity, the space required for the scrubber is considerably less than for conventional systems and this, too, was appealing to Thilmany as the space available near the center of the pulp mill was very limited.

3. *Trouble-Free Continuous Operation.* Previous experience with the water venturi scrubber on the 120-ton unit had been completely satisfactory and its operation had required little or no attention, yet it operated continuously at about 90% efficiency.

4. *High Chemical Recovery Efficiency.* Pilot-plant operation using concentrated black liquor as the scrubbing medium in the venturi scrubber had indicated that saltcake recovery of 90% could be expected.

5. *Maximum Heat Recovery.* This was a very important consideration because it would help solve the problem of additional evaporating capacity with a minimum of expense. It was calculated that the additional heat recovery obtained in the venturi scrubber, by decreasing the exit flue gas temperature about 100°F. below that normally attained with conventional direct evaporators, would make it possible to decrease the concentration of the liquor leaving the multiple effect evaporator from about 50% solids to the desired 40% solids. The resulting decreased evaporating load, made possible by lowering the exit solids, combined with changes to effect about a 25% increase in the evaporating capacity of the multiple effect unit, would permit a daily pulp production in excess of 225 tons using the existing 165-ton evaporators. The necessity of purchasing another line of evaporators for increased capacity would thus be eliminated. (The 25% increase

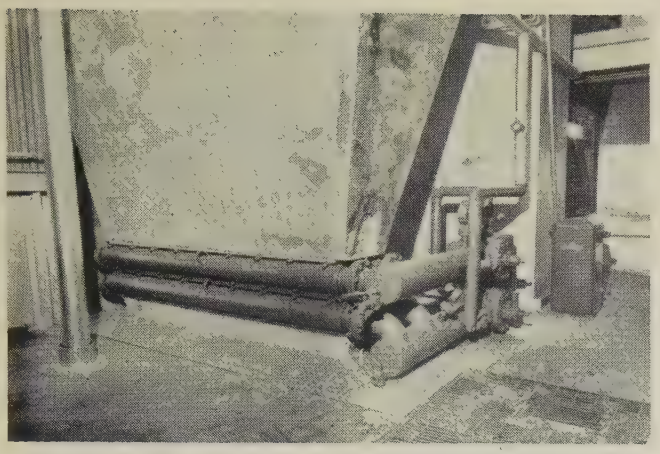

*Fig. 3. Closeup of venturi throat and header*

in evaporator capacity was accomplished by adding a few tubes in each effect and lengthening the tubes from 20 to 26 ft. in all but the first effect.)

In brief, from a chemical and heat recovery evaluation, the black liquor venturi scrubber appeared to offer the best recovery for the least over-all capital investment.

## FULL-SCALE BLACK LIQUOR VENTURI SCRUBBER

On May 5, 1953, the 250-ton recovery unit and the venturi scrubber were put on the line simultaneously, and they have operated continuously since then except for scheduled week-end shutdowns. An outline drawing of this equipment is shown in Fig. 1. This integrated recovery unit consists of the water wall furnace, boiler screen, superheater, boiler, economizer, gas air heater, forced draft fan, venturi atomizer, cyclone separator, flues, and induced draft fans.

Liquor of 62% solids is sprayed on the side and rear walls of the furnace where it is concentrated by direct heat from the gases of combustion to form a char which is nearly 100% dry fuel. This char cascades from the walls to the fuel bed on the furnace floor where the carbonaceous compounds burn in combination with 300°F. air from the air heater. As the black liquor char burns, a majority of the chemical contained in it is released and flows as smelt into the dissolving tank to form green liquor.

The hot gases, resulting from combustion of the liquor, rise from the burning bed and pass through the boiler screen, superheater, boiler, economizer, air heater, venturi atomizer, cyclone separator, and induced draft fans. The gases leaving the air heater still contain recoverable sensible heat and a small percentage of the chemical originally contained in the black liquor. Maximum recovery of this heat and chemical from the flue gases by the venturi scrubber increases the economic value of this recovery unit.

Figures 2, 3, 4, and 5 are photographs of the component parts of the venturi scrubber.

The black liquor venturi scrubber is shown in diagrammatic form in Fig. 6. It consists basically of an 8-in. by 7.5-ft. rectangular venturi atomizer and a 15-ft. diameter by 45-ft. cyclone separator. Black liquor at 42% solids from the multiple effect evaporators is admitted through a level control valve to the reservoir at the bottom of the separator where it mixes with the circulating liquor to attain the system equilibrium concentration of approximately 62% solids. A centrifugal pump having a capacity of 2000 g.p.m. at 132-ft. head circulates liquor from the base of the separator through an 8-in. basket strainer, with a motorized scraper, to the venturi throat and to wall-washing nozzles at the top of the separator. Scrapings from the strainer are carried to the mixing tank with the liquor for the furnace. Relative quantities of liquor fired in the furnace, sprayed at the venturi atomizer, and used for washing the cyclone walls are shown in Fig. 6. A spare pump and strainer insure continuity of service. Black liquor enters the venturi throat through seventy $^1/_4$-in. orifices, with splash plates, from a header on each side of the throat. An extra set of headers, provided to permit cleaning one while operating with the other, has not been used since the initial testing period. The liquor is further atomized by, and mixed with, the dust-laden flue gases passing through the throat at high velocity. This intimate mixing results in collection, by the liquor, of chemical particles from the gases. At the same time the gas temperature is reduced from approximately 485 to 180°F., and the liquor concentration is increased correspondingly. The mixture of liquor and gas passes to the cyclone separator where the liquor and collected chemical are centrifugally removed from the gas stream. The separated liquor and the wall-washing liquor run down the cyclone walls to the reservoir, thus completing the liquor cycle. The relatively clean, saturated gas flows from the top of the separator through two 100,000-c.f.m. induced draft fans. These units, operating in series to develop 40 in. static pressure, discharge the gas into a 200-ft. concrete stack.

Recovery efficiency in the venturi scrubber is primarily a function of draft loss across the venturi atomizer. In turn, draft loss is a function of liquor and gas flow

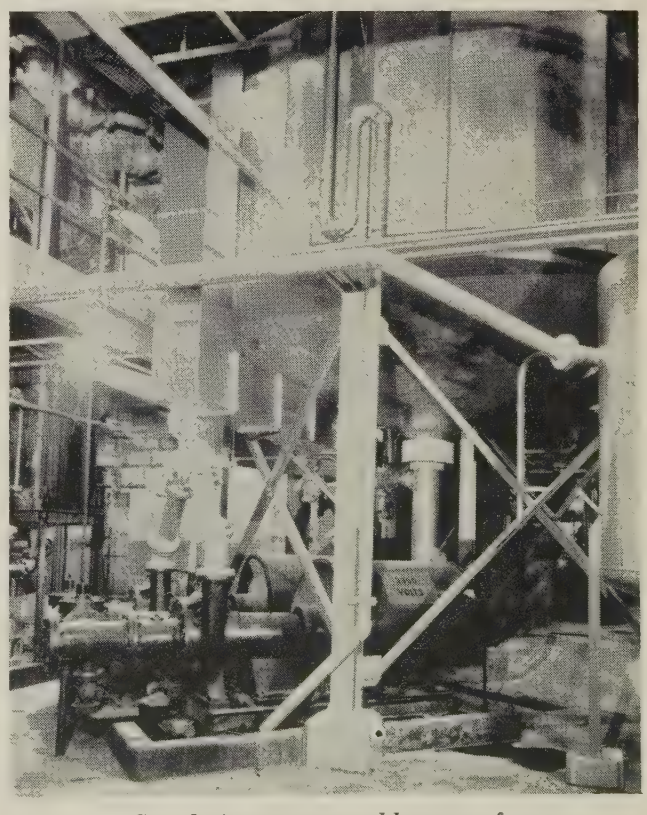

*Fig. 4. Circulating pumps and bottom of separator*

**Table I. Venturi Scrubber Performance Data**

| | *To scrubber* | | *From scrubber* |
|---|---|---|---|
| Black liquor flow, lb./hr. to furnace | .. | 50,000 | .. |
| Liquor pressure at venturi header, p.s.i. | .. | 30 | .. |
| Draft loss across venturi throat, in. water | .. | 30 | .. |
| Draft loss across separator, in. water | .. | 4 | .. |
| Flue gas temperature, °F. | 485 | | 180 |
| Black liquor temperature, °F. | 190 | | 180 |
| Black liquor solids, % | 42 | | 62 |
| Dust loading, std. dry gas, grains/cu. ft. | 5.87 | | 0.66 |
| Dust loading, stack conditions, grains/cu. ft. | 3.90 | | 0.40 |
| Collection efficiency, based on std. dry gas loadings, % | .. | 89 | .. |
| Saltcake loss, lb./day | .. | 4500 | .. |

rates. To maintain consistently high chemical recovery, the sole operating adjustment is to regulate the liquor flow rate at the venturi throat in accordance with the gas flow which depends upon the liquor firing rate. This regulation of liquor flow is made at the recovery unit operating panel by means of a remote controlled valve in the recirculating line.

## RESULTS

During the first few months' operation, frequent venturi scrubber tests were run by a four-man crew and scrubbing efficiencies ranged from 70 to 90%. Testing procedures employed were similar to those outlined by B&W (*5*, *6*) and Collins (*7*). As a result of these tests, some minor changes were made to the equipment, particularly the spray pattern in the venturi atomizer. These runs also helped determine the best operating procedure for obtaining the highest chemical and heat recovery efficiency.

When these studies were completed, a series of eight comprehensive tests, made during a typical week's operation, indicated chemical recovery efficiencies of approximately 90%, in addition to a bonus heat recovery sufficient to eliminate evaporating 12,000 lb. per hr. of additional water in the multiple effect evaporators thereby saving more than 3000 lb. of steam per hour.

A brief summary of the data is shown in Table I.

## CONCLUSIONS

Nineteen months of highly satisfactory performance

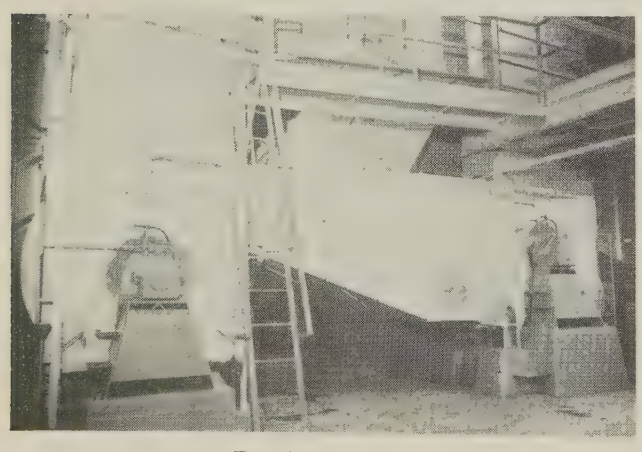

*Fig. 5. I.D. fans*

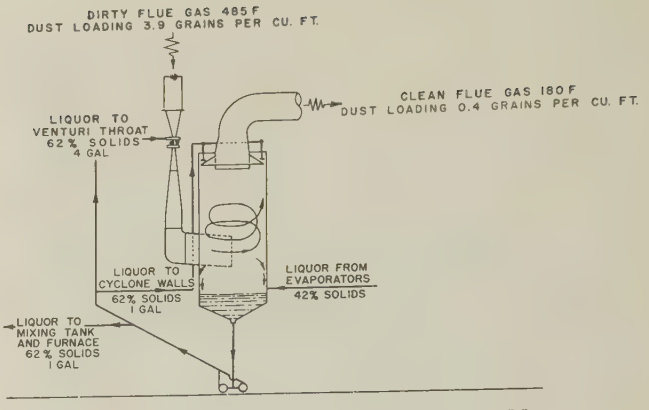
DIRTY FLUE GAS 485 F
DUST LOADING 3.9 GRAINS PER CU. FT.
CLEAN FLUE GAS 180 F
DUST LOADING 0.4 GRAINS PER CU. FT.
LIQUOR TO VENTURI THROAT 62% SOLIDS 4 GAL
LIQUOR TO CYCLONE WALLS 62% SOLIDS 1 GAL
LIQUOR FROM EVAPORATORS 42% SOLIDS
LIQUOR TO MIXING TANK AND FURNACE 62% SOLIDS 1 GAL

*Fig. 6. Flow diagram of venturi scrubber*

of the entire recovery unit have unquestionably demonstrated that the decision to follow the conventional recovery furnace with a black liquor venturi scrubber was an excellent one.

Its relatively low capital investment and minimum space requirements, which were major factors in Thilmany's decision, should make this new type of recovery equally attractive to the entire kraft pulp industry.

As was expected, the operation of this equipment has proved as trouble-free as that of the first full-scale water venturi scrubber which performed very well for nearly 6 years. An operator and a helper operate the complete recovery unit, including the scrubber, which requires no operating attention other than an hourly check by the helper to record the black liquor atomizing pressure at the venturi throat. All controls required for operating adjustments to the venturi are located at the main recovery unit panel board. The fact that dust or chemical is collected directly by or in the black liquor, where it is ultimately wanted, simplifies the over-all operation.

Although gases leaving the recovery boiler proper are cooled by the scrubber to, or very nearly to, their dewpoint, there have been no indications to date of undue corrosion or of "raining" in the stack.

Perhaps the most serious objection to the venturi scrubber is its rather high power requirement which is about three times that of a conventional system.

Thilmany believes that the venturi scrubber has proved itself capable of meeting the two prime requisites of a good recovery unit, namely, high chemical collection efficiency and maximum heat recovery.

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# Corrosion of Cable Armors in Paper Mills

B. J. MULVEY and J. F. QUINLAN

**In the papermaking industry there has been an increasing use of armored cable for power applications up to 15,000 v. The severe corrosion problems that exist in that industry require very careful choice of metals for the cable armor. To determine which metals are suitable there were exposed small samples of 13 different metals and alloys including four types of aluminum, three each of stainless steel and bronze, two of nickel, and one of monel metal. The samples were exposed in what was considered typically corrosive atmospheres in each of two paper mills. One mill makes paper by the sulphate and the other by the sulphite process. The samples were cleaned and weighed at periodic intervals to determine the degree of damage as function of exposure times. The test results indicate that aluminum is a good choice for cable armor in the locations tested. The degree of corrosion with aluminum was comparable to that of the stainless steels, but the "pitting" was considerably less. Since the cost of aluminum is considerably less than other corrosion-resistant metals it has become an economical choice for cable armor in paper mills. Incidental confirmation of the test data exists in the successful use of aluminum alloy window sashes, hand rails and stair treads in one eastern mill. For applications in locations with very heavy alkali or chlorine contamination, the use of a polyvinyl chloride outer jacket over the armor is considered.**

IN MANY paper mills, as in other industrial installations, armored cable is often used for power distribution. The cable, which is available in ratings up to 15,000 v., usually consists of three varnished cambric insulated conductors with a moisture and corrosion-resistant polyvinyl chloride thermoplastic jacket over the cabled conductors. Over the sheath is an interlocking metal tape for outer protection against mechanical injury (see Fig. 1). Such a cable construction with suitable accessories—terminal fittings, racks, etc.—lends itself to considerable economy in many installations.

In the pulp and paper industry with its many corrosion problems, the choice of metal for the cable armor is a serious problem. Some highly corrosion-resistant metals that might be considered are rejected for use because they are extremely difficult to work mechanically in forming the armor. Others are extremely expensive or difficult to obtain in quantity.

A metal chosen for cable armor must meet several requirements: (1) it should resist the various corrosion conditions at least to the extent that with reasonable maintenance a life of 20 to 25 years can be expected; (2) it should be obtainable in such quantity that, in times of stress, priorities, allotments, etc. will be at a minimum; (3) it should not be too expensive.

Prior to 1949 a number of armored cable installations were made using commercial bronze as the armor metal. In general, this material has proved satisfactory; in certain extremely corrosive locations, however, it has been found advisable to protect the cable with a coating of neoprene-base paint applied after installation. No cable failures due to armor deterioration have occurred.

Bronze as a cable armor is quite expensive, adding 10 to 15% to the cost of a cable as compared to galvanized steel. While it has proved relatively successful in practice, the tests reported here show that it is not necessarily the best material for the application.

Until 1950 suitable techniques for applying aluminum interlocking armor in long lengths of cable were not available. With the development of such techniques, the use of cable armored with aluminum has increased markedly. Cost-wise such a cable is considerably less expensive than bronze-armored cable.

The tests described here were made to determine, if possible, which metals have resistance to paper mill atmospheres to a degree sufficient to warrant their use without further protection.

## METHOD OF ATTACK

Since it was necessary to gather experimental data in the field, two paper mills were chosen as the location for the experiments. The mills were chosen on the basis of cooperation, nearness to our laboratory, and the fact that one used the sulphate process while the other used the sulphite process in making paper.

The mills were the Hammermill Paper Co. at Erie, Pa., and the Champion Paper & Fibre Co., at Canton, N. C. To each mill was sent two racks, making a total of four racks in all. Each rack contained 13 metal specimens and four galvanic couples made up of combinations of the 13 metals.

Of the two racks sent to Hammermill, no. 1 was exposed in the acid building. The atmosphere of the acid building was moist and contained sulphurous gases and chlorine. Rack no. 2 was exposed over the blow-pits. This atmosphere contained the various acids of sulphur as well as organic acids.

Of the two racks sent to the Champion plant, no. 1 was exposed 80 ft. above the ground near the digester and reclaimer stacks. This was an outdoor location which was continually exposed to the moist gases from the digester and reclaimer stacks. Rack no. 2 was placed close to the lime kiln, turpentine stills, and hot liquor storage tanks, and was exposed to the gases from the lime kiln, chlorine absorber vent, hydrogen vent, hot liquor storage tanks, and turpentine stills.

At the Champion plant, the specimens were cleaned

*Fig. 1. Typical armored cable construction*

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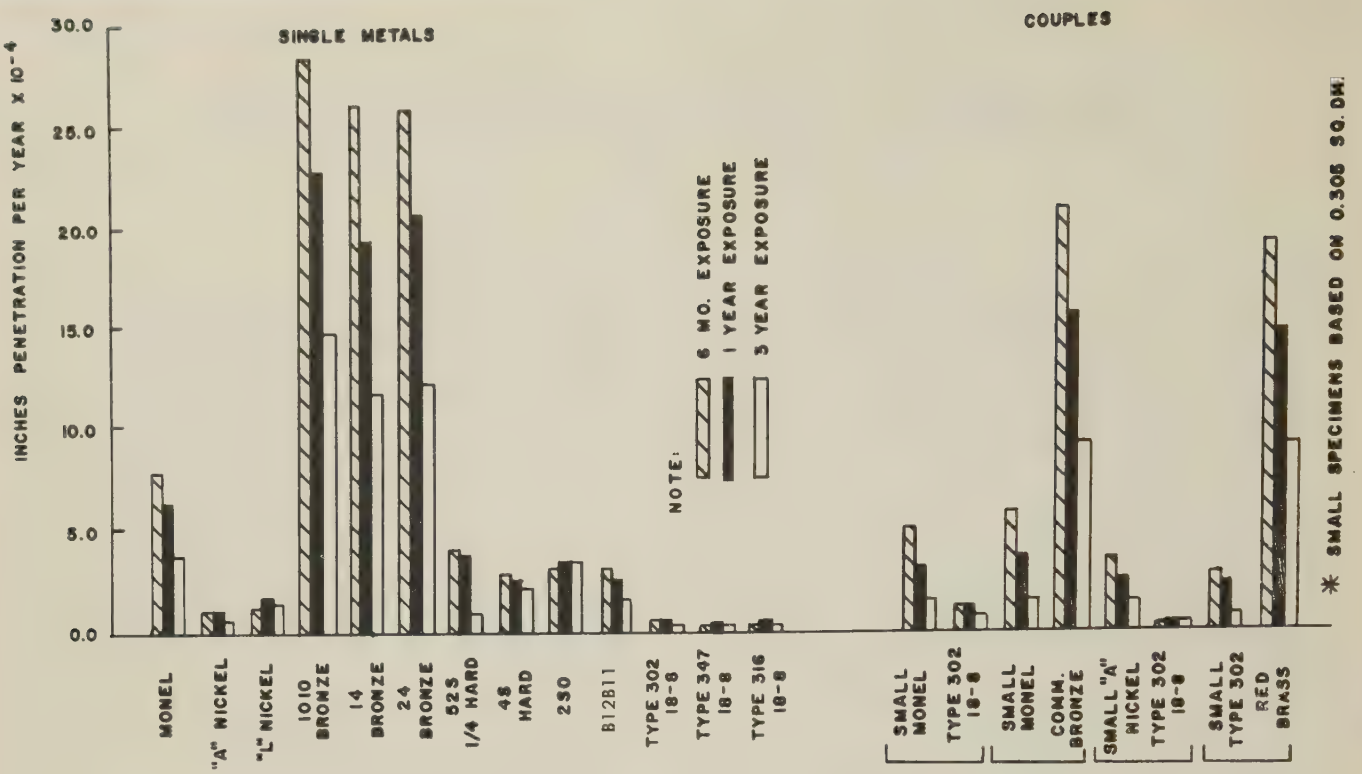


*Fig. 2. Rack no. 1, Canton, N. C.*

and weighed at the end of 6 months, 1 year, and 3 years. At the Hammermill plant they were cleaned and weighed at the end of 1 and 3 years. When a specimen was cleaned and weighed, it was returned to the same rack at the same location. Unfortunately, rack no. 2 from the Champion plant and rack no. 1 from the Hammermill plant were lost after the one-year weighing. Thus, no data on the 3-year level are available on these racks.

The racks used were the standard type referred to in the "Corrosion Handbook," edited by H. H. Uhlig (Wiley). After exposure, the metal disks were removed from the racks and cleaned using chemical methods outlined by Uhlig.

## DISCUSSION AND RESULTS

Tables I and II report the experimental results for the 1-year exposure of all four racks. Tables III and IV report the results for the remaining two racks at the end of 3 years' exposure. These tables are the tabu-

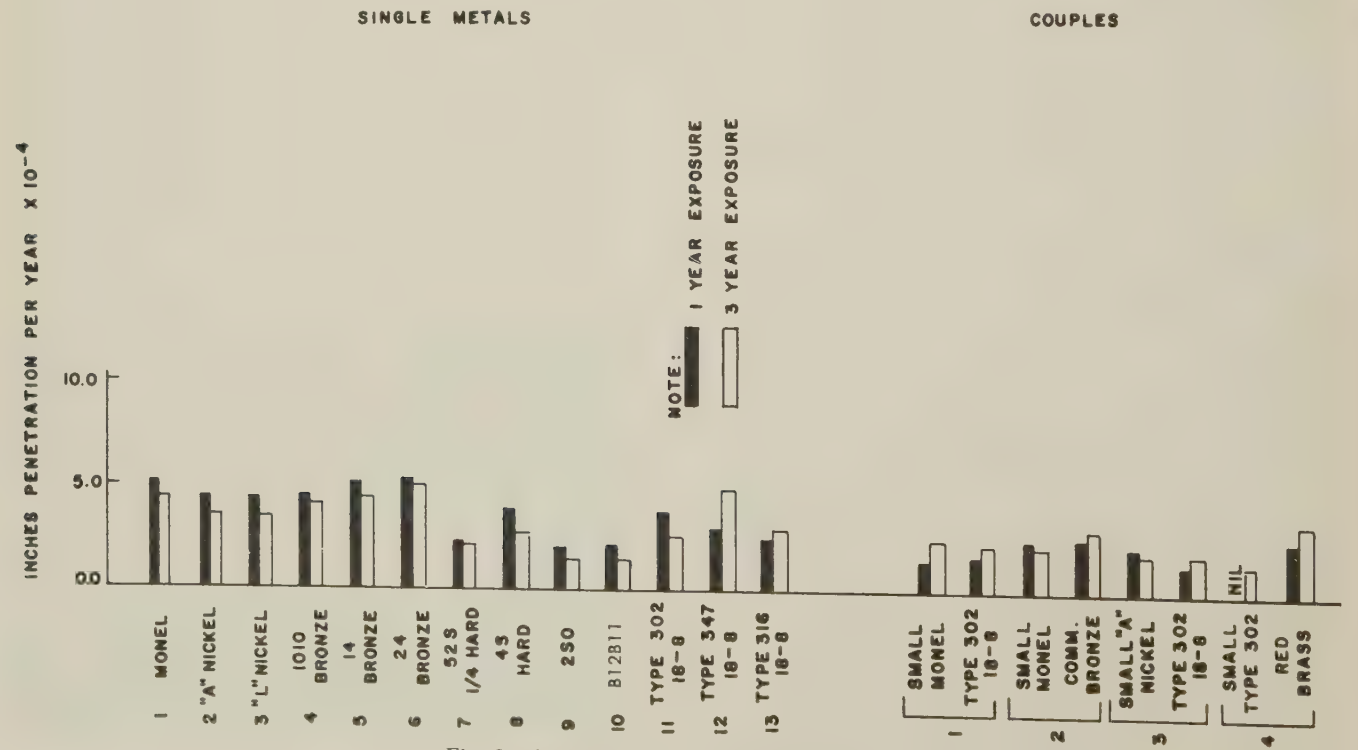


*Fig. 3. Rack no. 2, Erie, 3-year exposure*

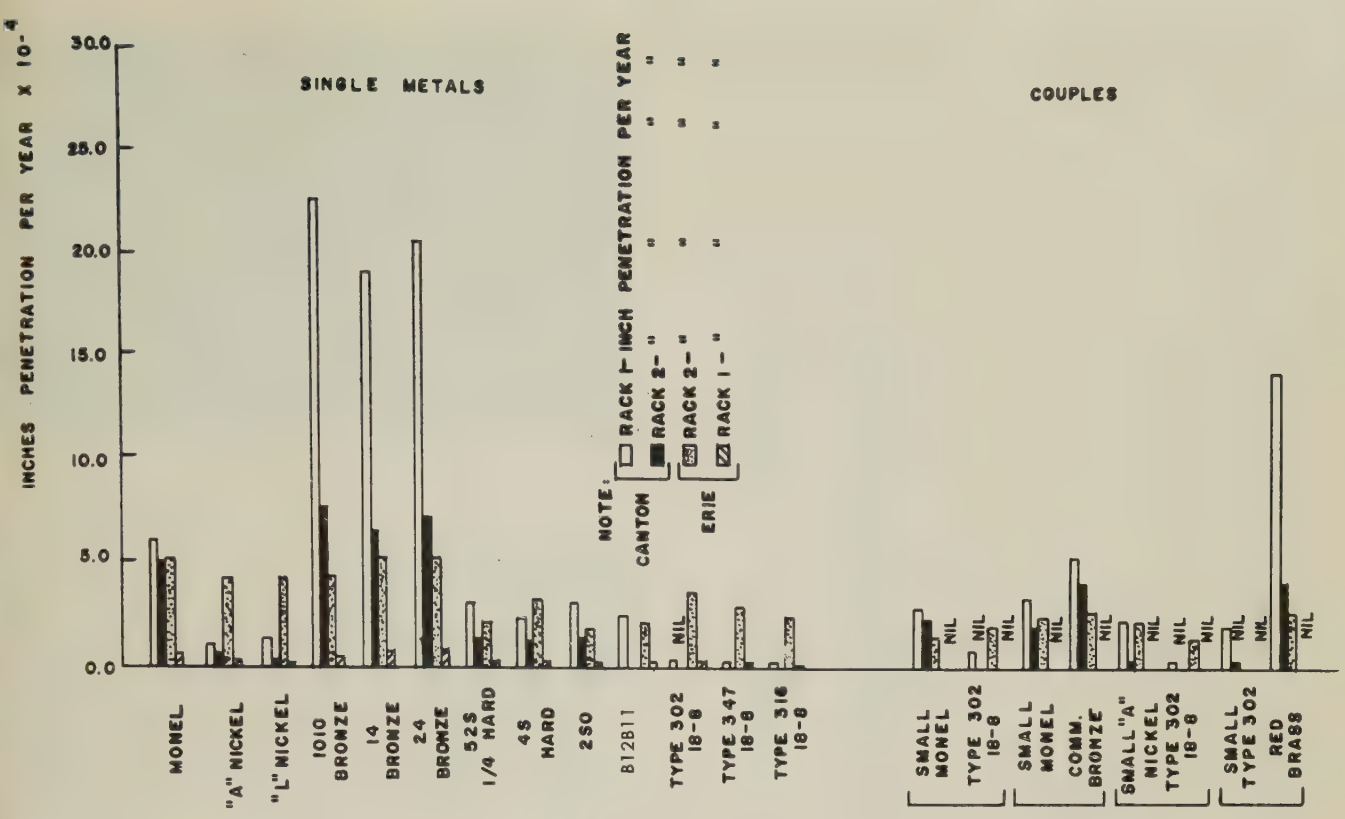


*Fig. 4. One-yr. exposure at Erie and Canton*

lated experimental results plus the calculated inches per year (i.p.y.) corrosion rate. The inches per year is calculated from the weight loss and in no way takes into account pitting.

Figures 2 through 5 are plots of rate-of-corrosion of various metals at various locations versus time of exposure. From Figs. 2 and 3 it can be concluded that the rate of corrosion decreases with increasing time. This point is emphasized when it is realized that the 3-year exposure is actually 2 years, for the surface of the metal had been cleaned at the end of 1 year and then re-exposed for the remaining 2 years. Thus, the metal surface film would be but 2 years old at the end of a 3-year exposure.

Figures 4 and 5 indicate that the corrosion rate varies widely with location in the plant, and furthermore, some metals resist corrosion in one atmosphere but fail rapidly in another. Thus it is important in choosing a metal to choose one that resists corrosion at all locations.

Figure 6 is a typical picture of the rack after an exposure. The metallic couples are at the top followed

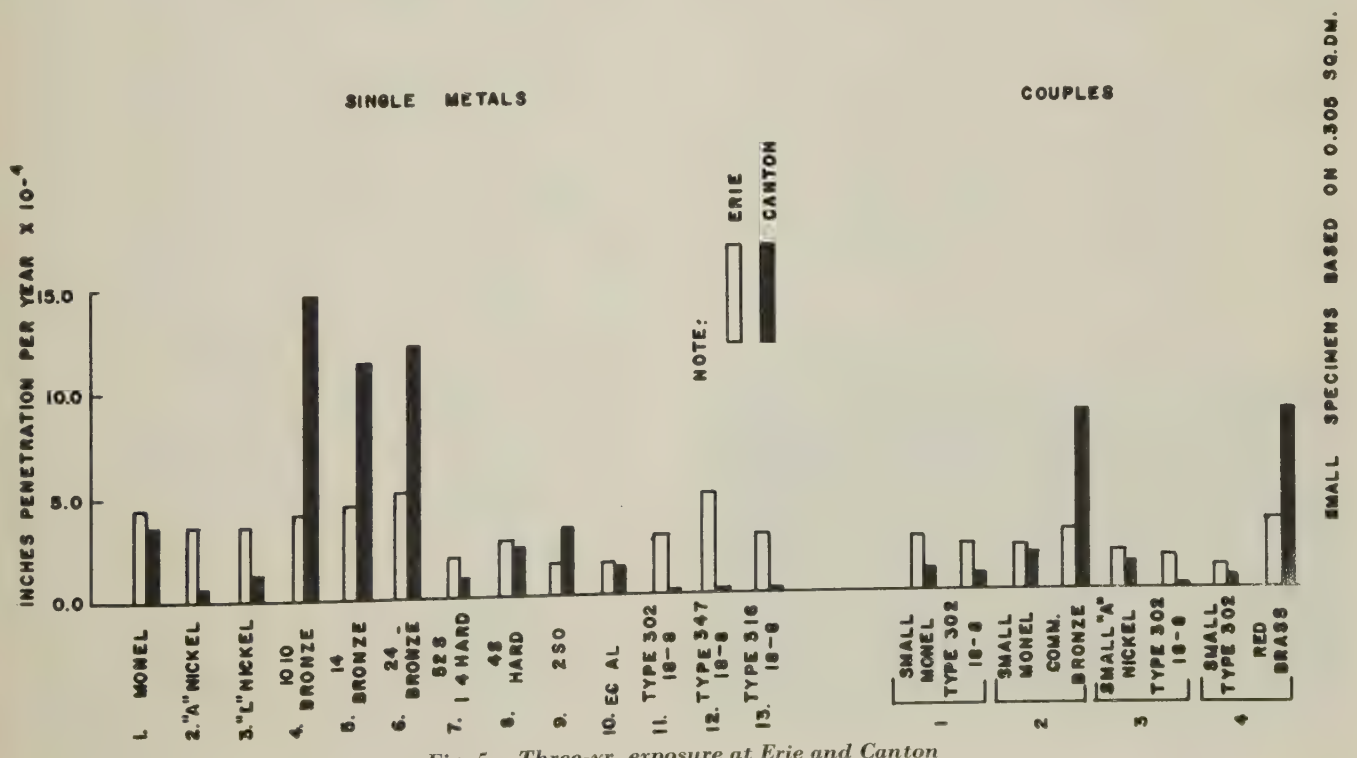


*Fig. 5. Three-yr. exposure at Erie and Canton*

**Table I. Paper Mill Corrosion Test Data—1-Year Exposure, Canton, N. C.**

| | Trade names of metal | Rack no. | Weight loss, g./0.5 sq. dm. | Average penetration, i.p.y. × $10^{-4}$ |
|---|---|---|---|---|
| | **Single Metals** | | | |
| 1. | Monel | 1 | 0.7209 | 6.4 |
| | | 2 | 0.5609 | 5.0 |
| 2. | "A" nickel | 1 | 0.1201 | 1.1 |
| | | 2 | 0.0419 | 0.4 |
| 3. | "L" nickel | 1 | 0.1541 | 1.4 |
| | | 2 | 0.0369 | 0.3 |
| 4. | 1010 bronze (Everdur) | 1 | 2.4975 | 22.8 |
| | | 2 | 0.8531 | 7.7 |
| 5. | 14 bronze (comm. bronze) | 1 | 2.2798 | 19.3 |
| | | 2 | 0.7063 | 6.4 |
| 6. | 24 bronze (red brass) | 1 | 2.3003 | 20.7 |
| | | 2 | 0.7929 | 7.1 |
| 7. | 52S aluminum (1/4 hard) | 1 | 0.1275 | 3.8 |
| | | 2 | 0.0471 | 1.4 |
| 8. | 4S aluminum (hard) | 1 | 0.0840 | 2.4 |
| | | 2 | 0.0368 | 1.1 |
| 9. | 2SO aluminum (annealed) | 1 | 0.1123 | 3.3 |
| | | 2 | 0.0448 | 1.3 |
| 10. | B12B11 (2S aluminum 1/2 hard) | 1 | 0.0891 | 2.6 |
| | | 2 | Lost | Lost |
| 11. | 302 stainless | 1 | 0.0325 | 0.3 |
| | | 2 | 0.0056 | Nil |
| 12. | 347 stainless | 1 | 0.0255 | 0.2 |
| | | 2 | 0.0116 | 0.1 |
| 13. | 316 stainless | 1 | 0.0267 | 0.3 |
| | | 2 | 0.0164 | 0.2 |
| | **Metallic Couples** | | | |
| 1. | (Small) (5) monel | 1 | 0.1999 | 2.9 |
| | | 2 | 0.1512 | 2.2 |
| | 302 stainless | 1 | 0.0992 | 1.0 |
| | | 2 | 0.0069 | Nil |
| 2. | (Small) monel | 1 | 0.2402 | 3.5 |
| | | 2 | 0.1360 | 1.9 |
| | Comm. bronze | 1 | 1.7127 | 15.5 |
| | | 2 | 0.4664 | 4.2 |
| 3. | (Small) "A" nickel | 1 | 0.1555 | 2.3 |
| | | 2 | 0.0139 | 0.2 |
| | 302 stainless | 1 | 0.0153 | 0.2 |
| | | 2 | 0.0071 | Nil |
| 4. | (Small) 302 stainless | 1 | 0.1251 | 2.0 |
| | | 2 | 0.0107 | 0.2 |
| | Red brass | 1 | 1.6277 | 14.6 |
| | | 2 | 0.4603 | 4.2 |

Small samples are 0.305 sq. dm., all others 0.500 sq. dm.

by the metals in the order of their numbers. It is interesting to note the heavy film of corrosion products which apparently coats each specimen.

Figures 7 through 10 are pictures of the 3-year specimens after they have been cleaned. A brief examination of them will reveal that the nickel group corrodes by surface attack with mild pitting. The bronze group corrodes with uniform surface attack and no pitting. The aluminum pits mildly with most of the corrosion being a uniform surface attack.

With the stainless steels, there is no general surface

*Fig. 6. Sample rack after exposure*

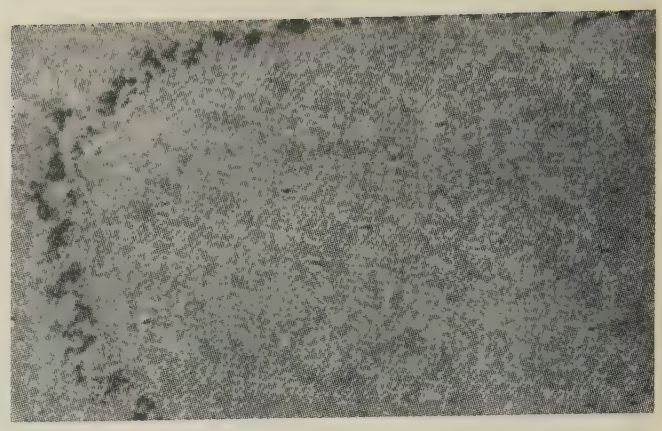

*Fig. 7. Aluminum (4S)*

corrosion. However, the attack proceeds by pitting and the incidence of pitting differs with the location. Those specimens exposed at the Champion plant were pitted in a few spots but the depth of the pits was great. The specimens exposed at the Hammermill plant were severely pitted and to a considerable depth.

For the purpose of cable armor, widely spaced pitting is relatively unimportant, for if the pits go through the metal, the plastic envelope will protect the electrical

**Table II. Paper Mill Corrosion Test Data—1-Year Exposure, Erie, Pa.**

| | Trade names of metal | Rack no. | Weight loss, g./0.5 sq. dm. | Average penetration, i.p.y. × $10^{-4}$ |
|---|---|---|---|---|
| | **Single Metals** | | | |
| 1. | Monel | 1 | 0.0593 | 0.5 |
| | | 2 | 0.5812 | 5.2 |
| 2. | "A" nickel | 1 | 0.0159 | 0.1 |
| | | 2 | 0.4715 | 4.2 |
| 3. | "L" nickel | 1 | 0.0146 | 0.1 |
| | | 2 | 0.4901 | 4.3 |
| 4. | 1010 bronze (Everdur) | 1 | 0.0509 | 0.5 |
| | | 2 | 0.4860 | 4.4 |
| 5. | 14 bronze (comm. bronze) | 1 | 0.0695 | 0.6 |
| | | 2 | 0.5747 | 5.2 |
| 6. | 24 bronze (red brass) | 1 | 0.0924 | 0.8 |
| | | 2 | 0.6058 | 5.4 |
| 7. | 52S aluminum (1/4 hard) | 1 | 0.0018 | Nil |
| | | 2 | 0.0781 | 2.3 |
| 8. | 4S aluminum (hard) | 1 | 0.0012 | Nil |
| | | 2 | 0.1328 | 3.8 |
| 9. | 2SO aluminum (annealed) | 1 | 0.0018 | Nil |
| | | 2 | 0.0674 | 1.9 |
| 10. | B12B11 (2S aluminum 1/2 hard) | 1 | 0.0012 | Nil |
| | | 2 | 0.0767 | 2.2 |
| 11. | 302 stainless | 1 | 0.0018 | Nil |
| | | 2 | 0.2807 | 3.8 |
| 12. | 347 stainless | 1 | 0.0038 | Nil |
| | | 2 | 0.3004 | 3.0 |
| 13. | 316 stainless | 1 | 0.0022 | Nil |
| | | 2 | 0.2523 | 2.5 |
| | **Metallic Couples** | | | |
| 1. | (Small) (5) monel | 1 | 0.0169 | Nil |
| | | 2 | 0.1095 | 1.6 |
| | 302 stainless | 1 | 0.0012 | Nil |
| | | 2 | 0.1791 | 1.8 |
| 2. | (Small) monel | 1 | 0.0134 | Nil |
| | | 2 | 0.1648 | 2.4 |
| | Comm. bronze | 1 | 0.0396 | Nil |
| | | 2 | 0.3016 | 2.7 |
| 3. | (Small) "A" nickel | 1 | 0.0036 | Nil |
| | | 2 | 0.1555 | 2.3 |
| | 302 stainless | 1 | 0.0002 | Nil |
| | | 2 | 0.1387 | 1.4 |
| 4. | (Small) 302 stainless | 1 | 0.0048 | Nil |
| | | 2 | 0.0138 | Nil |
| | Red brass | 1 | 0.0476 | Nil |
| | | 2 | 0.2986 | 2.7 |

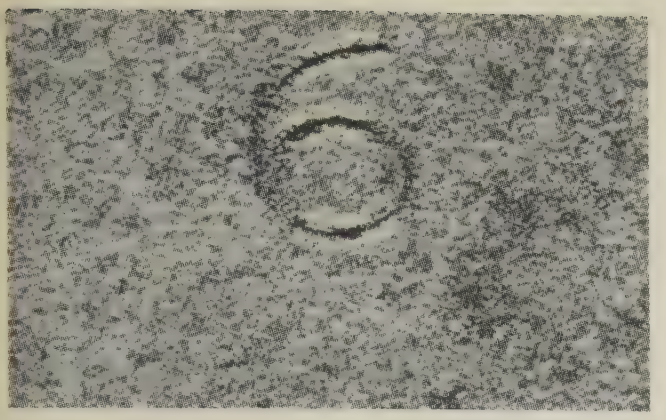

*Fig. 8. 24 Bronze (Red brass)*

components almost indefinitely. What is important is that the armor does not break or wear off. Widely spaced pitting does not seriously impair the strength of armor, but when the incidence of pitting and depth of pitting are great, then the material is weakened per unit weight lost. This can readily be seen if one considers a sheet of material with holes drilled at random. At some points the concentration of the holes will be greater than average, and at other points the concentration of holes will be less. Where the concentration of holes is greater the armor will be weaker. Thus, severe pitting will actually weaken a material more than uniform corrosion.

The stainless steels sent to Erie are so badly pitted that it would be unwise to use them as armor. However, all the other materials are free from pitting which would be severe enough to rule them out.

The location plays a very important part in the corrosion rate of a material. At the Hammermill plant, all the aluminum samples resisted corrosion quite well, while at the Champion plant, the stainless steel made the best showing followed by the nickels. Thus, in choosing a material it is necessary to consider its resistance to the corrosive atmosphere at all possible locations.

**Table III. Paper Mill Corrosion Test Data—3-Year Exposure, Canton, N. C.**

| | *Trade names of metal* | *Rack no.* | *Weight loss, g./0.5 sq. dm.* | *Average penetration, i.p.y. × $10^{-4}$* |
|---|---|---|---|---|
| | Single Metals | | | |
| 1. | Monel | 1 | 1.224 | 3.6 |
| 2. | "A" nickel | 1 | 0.1749 | 5.2 |
| 3. | "L" nickel | 1 | 0.6653 | 1.1 |
| 4. | 1010 bronze (Everdur) | 1 | 4.894 | 14.7 |
| 5. | 14 bronze (comm. bronze) | 1 | 3.766 | 11.3 |
| 6. | 24 bronze (red brass) | 1 | 4.023 | 12.2 |
| 7. | 52S aluminum (1/4 hard) | 1 | 0.9030 | 0.9 |
| 8. | 4S aluminum (hard) | 1 | 0.2432 | 2.2 |
| 9. | 2SO aluminum (annealed) | 1 | 0.3440 | 3 3 |
| 10. | B12B11 (2S aluminum 1/2 hard) | 1 | 0.1127 | 1.1 |
| 11. | 302 stainless | 1 | 0.0632 | 0.2 |
| 12. | 347 stainless | 1 | 0.0603 | 0.2 |
| 13. | 316 stainless | 1 | 0.0645 | 0.2 |
| | Metallic Couples | | | |
| 1. | (Small) (5) monel | 1 | 0.2523 | 1.2 |
| | 302 stainless | 1 | 0.1907 | 0.6 |
| 2. | (Small) monel | 1 | 0.3664 | 1.8 |
| | Comm. bronze | 1 | 2.9405 | 8.8 |
| 3. | (Small) "A" nickel | 1 | 0.2161 | 1.0 |
| | 302 stainless | 1 | 0.0349 | 0.1 |
| 4. | (Small) 302 stainless | 1 | 0.1121 | 0.6 |
| | Red brass | 1 | 2.921 | 0.7 |

**Table IV. Paper Mill Corrosion Test Data—3-Year Exposure, Erie, Pa.**

| | *Trade names of metal* | *Rack no.* | *Weight loss, g./0.5 sq. dm.* | *Average penetration, i.p.y. × $10^{-4}$* |
|---|---|---|---|---|
| | Single Metals | | | |
| 1. | Monel | 2 | 1.480 | 4.4 |
| 2. | "A" nickel | 2 | 1.171 | 3.5 |
| 3. | "L" nickel | 2 | 1.204 | 3.6 |
| 4. | 1010 bronze (Everdur) | 2 | 1.351 | 4.1 |
| 5. | 14 bronze (comm. bronze) | 2 | 1.472 | 4.4 |
| 6. | 24 bronze (red brass) | 2 | 1.649 | 4.9 |
| 7. | 52S aluminum (1/4 hard) | 2 | 0.2190 | 2.1 |
| 8. | 4S aluminum (hard) | 2 | 0.2792 | 2.7 |
| 9. | 2SO aluminum (annealed) | 2 | 0.1546 | 1.5 |
| 10. | B12B11 (2S aluminum 1/2 hard) | 2 | 0.1500 | 1.5 |
| 11. | 302 stainless | 2 | 0.8040 | 2.7 |
| 12. | 347 stainless | 2 | 1.4703 | 4.9 |
| 13. | 316 stainless | 2 | 0.8182 | 2.7 |
| | Metallic Couples | | | |
| 1. | (Small) (5) monel | 2 | 0.5025 | 2.5 |
| | 302 stainless | 2 | 0.6766 | 2.2 |
| 2. | (Small) monel | 2 | 0.4062 | 2.0 |
| | Comm. bronze | 2 | 0.9820 | 2.9 |
| 3. | (Small) "A" nickel | 2 | 0.3915 | 1.9 |
| | 302 stainless | 2 | 0.5290 | 1.7 |
| 4. | (Small) 302 stainless | 2 | 0.2087 | 1.1 |
| | Red brass | 2 | 1.1422 | 3.4 |

The best all-around material appears to be B12B11 aluminum or 52S 1/4 hard aluminum. Certainly, the worst materials would be the bronzes. The stainless steels can be eliminated on the basis of pitting and the monel nickel group does not appear to be as resistant overall as the aluminum group.

It is interesting to note that the couples generally show less corrosion than single metals themselves. The reason that less apparent corrosion occurs on the couples than on the single specimen is that the metals of the couples were placed so closely together that there was no corrosion on adjacent faces.

Since the aluminums are apparently the best material, it is unfortunate that the tests did not include metallic couples with aluminum as one of the metals.

From time to time, the question of coating the armor with a corrosion-resistant lacquer arises. This may be unwise as the lacquer will be scratched off during installation. The scratched places will set up concentration cells which will literally cut the metal at the line of scratch. Some mills have used the factory applied asphalt-base lacquer as a prime coat for further painting applied after installation.

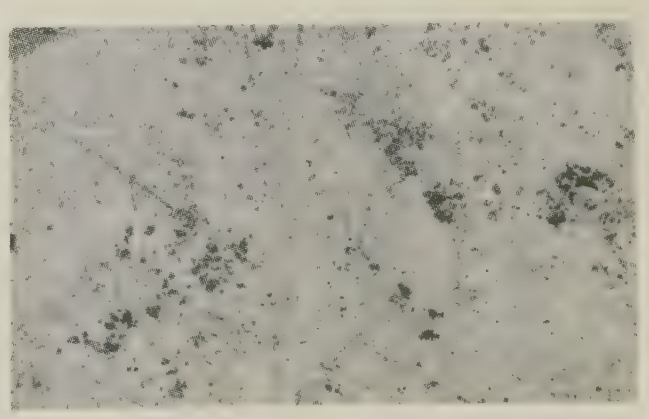

*Fig. 9. "A" nickel*

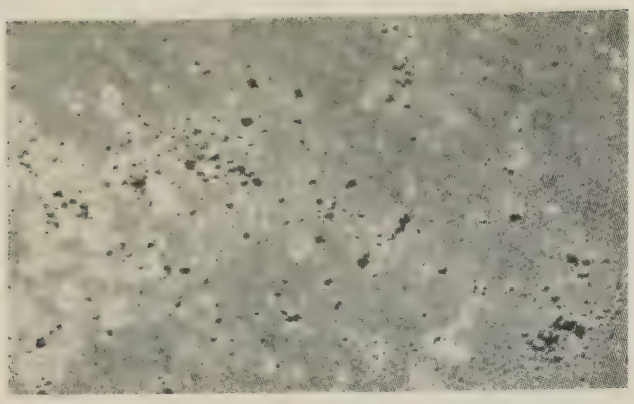

*Fig. 10. Type 302 stainless steel*

## CONCLUSIONS

On the basis of these tests, the best metal for cable armor in a paper mill is either B12B11 (25-1/2 hard aluminum) or 52S 1/4 hard aluminum. The 4S hard or 2SO are about on a par with monel and the nickels. Bronze does not show up too well but it does corrode uniformly and does not pit. The stainless steels pit severely.

These conclusions are valid to the extent that the positions of exposure that were selected are representative of the corrosive atmospheres encountered in paper mills.

Needless to say, if aluminum were exposed to caustic or highly alkaline media its life would be short.

While the data shown here represent an attempt at quantitative evaluation of various metals, other experience exists which tends to confirm the conclusion that aluminum (2SO) and some alloys stand up well in paper mill atmospheres. At one large mill in Maine, power is brought into the plant over high voltage open wire lines. The conductors are ACSR (aluminum cable, steel reinforced). The lines pass through an area that is highly contaminated with a variety of mill fumes. After 20 years' operation the conductors are still in service. They have a coating of black corrosion which formed early in the exposure and has evidently served to protect the aluminum from serious degradation.

Another confirming report was received by one of the authors. A large southern mill located on the Atlantic Coast has for several years used extruded aluminum window sashes (61T6 alloy) in the mill's recovery plant. After approximately 3 years' exposure, they show promise of indefinitely long life. The same mill uses aluminum alloy handrails, conveyor guard-rails, and stair treads with equal success.

Nevertheless, there is probably no metal that is not affected in some way or another by corrosion. Ultimately it is hoped that a suitable method will be developed for factory-coating the armor metal with, say, a 40 or 50-mil thickness of polyvinyl chloride. Such a coating would withstand almost any chemical likely to be used in the paper industry. Such a coating, however, would have to be flexible enough to remain in intimate contact with the armor surface during flexing of the cable, yet tough enough to withstand the normal abuse encountered in pulling the cable into racks, troughs, etc. Development work on this problem continues.

The authors wish to acknowledge with gratitude the fine cooperation given by the Champion Paper & Fibre Co. and the Hammermill Paper Co. in helping obtain the information reported here.

# Vibration Instrumentation

ARTHUR R. CRAWFORD

**A survey of presently employed techniques in industry's approach to vibration analysis and balance problems indicated a pressing need for adequate instrumentation. Many standards are employed in manufacturing processes today; however, no adequate standards of vibration and balance have been instigated, and no equipment has been available to measure and maintain such standards. Equipment is developed which is reliable in its operation and presents the parameters of displacement, frequency of the maximum component of vibration, and phase of the unbalance with great simplicity of operation. A new concept was employed in the development of this equipment, departing from the old sine-wave approach to balance problems and resulted in a simple, yet accurate means of analyzing a complex vibration problem as well as performing dynamic balancing operations.**

SINCE the day on which Congress ruled that "12 barley corns round and dry laid end-to-end shall constitute 1 ft." the problem of measurement has been of paramount importance in all industrial progress. The accuracy and speed with which measurements can be made bear a direct relationship to the accuracy and speed of industrial progress. The never ceasing struggle for increased production speeds, efficiency, and quality have placed an ever increasing burden upon the manufacturer to provide both adequate standards and tolerances of production and the equipment necessary to maintain these standards and these tolerances.

Many may recall the advent of the micrometer and its effect upon machine shop practices. When first introduced many of the old time machinists contended that they could measure as accurately and as rapidly with their calipers as any newcomer could do with his micrometer. A rather lengthy transition period followed, as it usually does after the introduction of any new technique, in which many organizations accepted the micrometer as a means of measuring machining tolerances only after being forced to do so by the increased accuracies required by their customers. It eventually became apparent that a machine shop which was not equipped with micrometers was not in a position to meet the standards or the accuracies required by modern industry.

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This advancement has continued until recent technological advances have relegated to insignificance most operations which depend for their accuracy upon individual judgment. If we were to take, for example, the present day production of a modern machine tool we would note a tremendous application of tolerances and standards of both a dimensional and a constructional nature. Every conceivable dimension is checked and rechecked, all machining tolerances are carefully observed, chemical composition is strictly adhered to in materials employed during construction, and final tests are made to insure the highest possible quality and workmanship. Components of this machine tool are rejected for a great variety of reasons; however, this rejection for the most part is based upon scientific instrumentation adequate to meet the requirements of the tolerances specified.

## USUAL APPROACH

Completely out of place in this picture of a careful application of controls and standards is the common practice of basing the final acceptance of this same machine tool from the standpoint of vibration or unbalance upon individual human judgment. Many, many manufacturers today, however, after employing all of the standards and tolerances observed above, base the final acceptance of their product upon an inspector's individual feel or judgment. Many cases arise where the finished product is acceptable to one inspector, but not acceptable to another. This in itself is sufficient to rule out such a method of providing a standard of vibration in any manufacturing process.

It must also be admitted that all of the multitudinous factors which affect human judgment come into play in just such a situation as this. The attitude of the inspector toward his company or his fellow employees, his home life, the type of day, the conditions under which he works, and many others all play an important part in the decision which he makes on the products or processes under his inspection.

In order to somewhat alleviate this embarrassing situation, some manufacturers have allowed their inspection personnel to set up whatever standards they see fit to maintain some semblance of a vibration tolerance in their equipment. For example, one manufacturer provides that a $^1/_4$ in. bolt, 1 in. long, when stood on its head on the main bearing of his mill must remain upright during operation in order to pass inspection; another provides that a penny must remain on its edge when placed on the pillow blocks of his spinning machine; and still another indicates that listening with the ear, feeling with the fingertip, or watching with the eye is a sufficient standard, provided that it is always performed by the same individual under the same conditions. These standards, of course, cannot be considered either scientific or academic, and as such could not be advertised as an indication of quality in the finished product. A good simile could be drawn from the case of the machine tool builder mentioned above if it were assumed that a customer, in complaining about the vibration level in this product, were told that such a situation could not exist because the chief inspector had placed his hands upon the machine and pronounced it good. No manufacturer would say such a thing to his customer; and because of just such a situation as this the problem of vibration tolerance, and even balance itself, in a great majority of finished products today is one which cannot be adequately substantiated and many times is even considered taboo.

In addition to the effects upon the customer and upon the manufacturer due to the lack of vibration standards or tolerances, it must be admitted that the correction of a vibration problem indicated in the manner illustrated above can necessarily be no better than the means employed to indicate the problem. In most cases when an inspector rejects a completed product due to a vibration level in the composite piece of equipment which to him appears to be unsatisfactory, the product must be disassembled a part at a time, and each part rebalanced in a dynamic balancing machine, since the inspector obviously has not been previously calibrated to determine accurately which one of a multiplicity of components is the source of trouble. In many cases, the resulting level of vibration in a completed product is not due entirely to unbalance or some other defect in one particular component, but is a summation of the vibrations of all of the components in operation together; thus, it is easily possible that even after the complete disassembly, balance, and reassembly of a complete machine tool the level of vibration may still be unacceptable to the inspector and, of course, would still present a problem of location to the engineering department. Such a process is not only time consuming and out of place in the light of present day standings on inspection and quality control, but is limited in its accuracy to the human judgment of the individual inspector.

## INDUSTRIAL EXAMPLE

An illustration of the process depicted above may be drawn from the experience of one of the nation's leading producers of bearings. A grinder which was at one time considered to be the best production tool in one division of this organization was suddenly found to be grinding bearings which the inspection department could not accept. The bearings ground by this machine, of course, did not reach the inspection department until many hundreds had been ground, all of which had to be scrapped. This discovery created a great amount of concern because of the past performance record of the machine.

After the problem had been discussed thoroughly, it was decided that a possible cause for this machine's malfunction might lie in vibration. Instrumentation was brought to bear upon the problem and it was deduced that the level of vibration at the grinder spindle was 0.008 in. peak-to-peak. This, of course, says no more than a doctor would say, were he to indicate that a patient's head hurt because he had a headache.

One of their maintenance personnel, due to his long experience and association with this particular type of grinding machine, knew by its characteristics that the trouble lay in the spindle bearings. After replacing the old spindle bearings with a new set, it was observed that the machine still ground bearings which were unacceptable to the inspection department. The maintenance engineer indicated that many, many times new bearings were as poor as old ones and replaced one set after another until 11 sets of spindle bearings had been

incorporated in this grinder with no visible signs of improvement.

He then was satisfied that the source of trouble did not lie in the bearings, and therefore must lie in the balance of the spindle itself. This was removed from the machine and balanced precisely in a modern up-to-date dynamic balancing machine. After reassembly the grinding machine still refused to produce bearings as it had before.

It then appeared to be intuitively obvious that the source of vibration must lie in the drive motor. This was removed, dismantled, balanced, resassembled, and replaced in the grinder machine again with no visible improvement. Many, many working hours were consumed in this blindfolded approach to a normal industrial vibration problem and much money was spent in this trial and error method of correction; however, the greatest loss to the organization lay not in the money expended in an effort to correct the problem, but lay in the tremendous loss in production from the grinding machine.

It is almost incredible in the light of present day scientific achievements that such a crude method should be used in the analysis and correction of industrial vibration problems. A possible explanation appears to lie in the fact that many industries have not given proper consideration to the importance of vibration elimination in their processes. Either they are not conscious of a vibration problem at all and the necessity of adequate vibration analysis equipment until a serious problem arises, or they do not feel that elimination of vibration is of value to their organization. An efficient, academic application of good vibration analysis and correction equipment to an entire process has proved time and time again to pay huge dividends in decreased maintenance costs, increased production, and increased quality of product.

### NEW INSTRUMENTATION NECESSARY

The crude approaches employed on both vibration analysis and dynamic balancing problems in a finished product or a maintenance application have placed great emphasis upon the development of adequate, scientific instrumentation to not only solve these problems, but to provide a reasonable standard of vibration tolerances.

One large manufacturer today actually publishes the fact that vibration instrumentation will accomplish valuable results when applied to his product in its original manufacture, but such instrumentation is too complicated to be operated by production personnel. On the other hand, the engineering department of this same organization has derived extensive mathematical formulas to be applied to the product in an effort to reduce the time necessary to locate and eliminate vibration in the completed mechanism. It is, of course, unreasonable to expect production personnel to manipulate these formulas with any anticipated degree of success, and thus, it becomes necessary to channel products which, to an inspector's judgment, appear to be unsatisfactory to the engineering department for examination and application of this mathematical poultice.

Although there appears to be a profuse amount of vibration indicating equipment available from many sources today, a stigma has arisen among the operating personnel of many, many organizations because equipment produced in the past has been used to solve problems for which it was not designed. In order to adequately meet the needs of any problem, equipment must be employed which is capable of furnishing the information necessary to lead the operator to the solution of his problem. For example, it would be incorrect to claim that a radio was not a useful product because it cannot transmit visual pictures, or to attempt to shoot an elephant with a gun designed for rabbits.

It becomes immediately apparent as the vibration problems of industry are considered today, that equipment has not been designed to meet the ever expanding needs of an industry which is geared to efficiency, speed, and competition. Although, as mentioned above, many pieces of vibration indicating equipment are available today, no equipment has, in the past, been designed to analyze a vibration problem in a complex mechanism. There have been many cases where a great deal of complicated scientific equipment has been used in conjunction with adequately trained engineering personnel, to aid in the analysis of a complex vibration problem; however, no single piece of equipment has been previously designed to place in the hands of the technician or the engineer, equipment expressly capable of measuring those parameters necessary in the solution of his problems.

A survey was made of the leading industries the country over, to determine the existing attitude toward vibration analysis and elimination and the equipment presently being employed in their approach to this phase of quality control. It was immediately obvious that in addition to the necessity of designing equipment capable of analyzing industrial vibration problems, it would be necessary to overcome the barrier existing in the minds of operating personnel who, in the past, have attempted to employ equipment insufficient to meet the needs of their problems and have thus become set against electronic vibration indicating equipment.

As the existing problems and the existing approaches were considered by the research department of the International Research and Development Corporation, it became apparent that in order to design equipment to adequately meet all the requirements, it would become necessary to depart from a basic premise employed in the design of previous well known equipment; that is, the premise that resulting vibration appears as a sine-wave. Equipment designed in the past has been directed toward the solution of a dynamic balancing problem, and not toward the analysis of a complex problem resulting from the vector summation of all components of vibration from a multiplicity of moving parts in a composite machine.

In the case of the machine tool builder mentioned above, it is not difficult to balance the headstock spindle of a lathe, once it is known that it is the headstock spindle causing the undesirable level of vibration in the completed machine. An obvious solution, of course, is to attempt to determine the frequency of the undesirable vibration and thus determine its source; however, as mentioned above, working on the basic premise that this vibration appears as a sine-wave, and thus as a single frequency, is working on a premise which in the majority of cases leads only to confusion. It has already been illustrated above, that many times the vibration

of a completed mechanism is not due primarily to one particular component, but is due to the summation of the vibration components from each particular part of this mechanism; thus, the resulting vibration would appear not as a sine-wave, but as a complex function composed of the vector summation of all of the components present in the device under study.

## NEW DESIGN

As these problems crystallized, and as the opinions of the nation's leading industries were sorted and considered, to aid in the design of adequate vibration instrumentation, it became further apparent that in order to completely solve the needs of industry, it would be necessary to develop equipment which would be simple to operate and readily understandable by average production personnel. In addition, it was decided that the three important parameters necessary in the solution of these vibration problems were the parameters of displacement, frequency, and phase. It must be emphasized here again that the frequency in this proposed equipment must be the frequency of the maximum component of vibration existing in the equipment under study, and that the displacement must be the peak-to-peak displacement of the resulting wave shape irrespective of any conditions as to whether or not it appeared as a sine-wave or as a complex function.

Several years of research were spent in the development of equipment geared primarily to those problems which are present in all industries relative to vibration elimination. The Vibration Analyzer was produced in its initial form, reading the peak-to-peak displacement, the frequency of the maximum component of vibration, and the phase of this maximum component of vibration.

Peak-to-peak displacement was, of course, not difficult to obtain by use of a peak reading circuit; however, to indicate the frequency of only the maximum component of vibration necessitated vigorous electronic design to develop a frequency channel, which would faithfully respond to only the maximum component of vibration present in a complex mechanism.

To indicate phase, several systems could be employed; however, it was apparent that several advantages could be obtained by employing the stroboscopic principle of phase determination. Thus, by firing a stroboscopic lamp in exact synchronism with the maximum component of vibration, it would not only be possible to determine the phase of the out of balance, but also to determine visually which particular component of a complex machine was causing the major portion of vibration existing as a complex wave form.

## USE OF EQUIPMENT

To adequately illustrate a typical application of the completely developed Vibration Analyzer, the solution of the grinding machine problem illustrated above can be used as a typical example. In just such an instance the vibration analysis equipment was brought to bear upon a grinder which had performed exactly an mentioned above, and which had been worked on by the engineering department of this manufacturer for approximately 6 weeks. The application of the Vibration Analyzer led the operator immediately to an endlessly woven nylon belt driving the spindle. This one source of vibration had been completely overlooked by the maintenance department of this organization; however, the Vibration Analyzer not being restricted by the limitations of human judgment and perception went directly to the source of the maximum component of vibration.

A normal application of the Vibration Analyzer includes, first of all, a probing application of the machine under study to locate the point of maximum displacement as observed on the displacement meter. The frequency of the maximum component of this peak-to-peak displacement will then appear, without calculation, on the frequency meter and the stroboscopic lamp will be triggered directly in synchronism with this maximum component of vibration. If the particular rotating or moving part causing the resulting maximum component of vibration is visible to the operator, it will appear to remain stationary due to the stroboscopic effect of the lamp, thus indicating immediately to the operator the particular component causing the maximum amount of vibration.

Since the Vibration Analyzer will also, by virtue of its stroboscopic lamp, indicate the phase of the out of balance, the operator, after locating the component causing the trouble, can actually perform a dynamic balancing operation without removing this component from its normal operating position. By actually running components in their normal conditions and at their normal speeds, it is possible to balance to any desired degree the entire piece of equipment. There are many obvious advantages to balancing a component under operating conditions other than those of speed and efficiency. Since there are no changes made after the balancing operation is completed, the level of vibration resulting after the balancing operation will not be changed due to moving the rotating component from a balancing machine into its normal operating position, or due to running at a speed other than that of the balancing operation.

The procedure followed by the operator in a balancing operation is broken down into four simple steps, so that no engineering background is required for successful operation of the equipment. The operator merely runs the component he desires to balance under normal operating conditions, and observes the phase of an arbitrary reference mark and the peak-to-peak displacement. He then applies a trial weight which, as a first approximation, is added in the direction in which he probes with the pickup of the Vibration Analyzer. On the second run, he observes the shift of the reference mark from its original observed position, and shifts the trial weight opposite to the shift of the reference mark, until he returns it to its original strobed position. He then has located precisely the angle of unbalance and has merely to increase or decrease the amount of weight until he has obtained the desired degree of balance. Four to six runs are usually all that are required for the complete operation as set forth above, but for those who are familiar with vector analysis it is possible to solve the problem after one run with a trial weight.

This simple four-step procedure can be followed by any operating personnel, and thus it is possible to place in the hands of the maintenance department, the inspection department, or the production department, accurate equipment which is capable of providing the information necessary to lead to the solution of any in-

dustrial vibration problem, and yet be so simple in its operation that no technically trained personnel are required. To further enhance the usefulness of this vibration analysis equipment, it has been ruggedly designed so that the manufacturer is able to cover this equipment with an unconditional 1-year guarantee on all parts including the tubes.

A representative cross section of the nation's leading industries has proved time and time again, that the application of this vibration analysis equipment has not only improved the quality of their product, reduced the maintenance time necessary in the elimination of vibration problems, and increased production but has also been economically feasible in every case. As industrial leaders the country over become cognizant of the vibration problems existing in their organizations and of the tremendous value of adequate vibration analysis equipment, this phase of measurement will stand with those of the past as being the final dimension or precision.

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# The Mechanical Properties of Paper—Part III

GEOFFREY BROUGHTON and JAMES P. WANG

**Handsheets were made by a carefully standardized technique from one lot of Douglas-fir bleached sulphate pulp. These were dried normally, by freeze-drying, or after water displacement by an organic solvent or by an aqueous solution of surface-active agent. At least 10 handsheets were made in any one series and broken or submitted to cycling on the Instron tensile testing machine. Reduction of the surface tension during drying either by a surfactant or freeze drying resulted in large drops of sheet strength as found earlier by other investigators. The presence of nonpolar liquids during drying also greatly reduced sheet strength. An interesting observation was made that such sheets when exposed to high relative humidity (85%) over long periods of time increased in strength to about the value obtained for a water-formed and normally dried sheet. The results are discussed from the standpoint of hydrogen bonding between cellulose fibers.**

Stress-strain studies of paper sheets, wet with a series of liquids of widely varying physical properties, were shown in Part II of this series (*5*) to be consonant with hydrogen bridging as the major factor in the bonding of the paper sheet. Such bonding can probably only occur first, if the fiber-to-fiber distance is of the order required for hydrogen bridging and second, if the surface environment for the formation of such bonds is suitable. The importance of the pulling together of the fibers and fibrils by capillarity during the drying of the paper sheet was pointed out by Boyd-Campbell (*2–4*) and has been emphasized by Stamm (*9*) and Van den Akker (*10*), the latter of whom also drew attention to the second factor of surface environment as an additional condition for the formation of strong bonds in the dry paper. By the use of conditions such that liquid water was not present, i.e., by sublimation or freeze-drying, Van den Akker was able to show that the strength of a paper handsheet dried in this way was only about 40% of that of an ordinary sheet in which the normal surface tension forces were active during drying. The importance of the second factor, surface environment during drying, is shown for example by some experiments of Cottrall (*6*) in which handsheets, made from pulp beaten normally, were steeped in ethyl alcohol in such a way that the water originally present in the sheets was practically wholly displaced by alcohol. After normal drying, these sheets were found to have a much higher opacity and only about one half the strength of the sheets made normally with water. Cottrall concluded that bonding had been largely eliminated. Kress and Bialkowsky (*7*) had earlier shown the effect of organic liquids upon beating and the ability to form a strongly bonded paper sheet.

In the present paper an attempt has been made to secure further experimental data on the factors affecting bonding.

## EXPERIMENTAL

All handsheets used in the present paper were made from one lot of Douglas-fir bleached sulphate pulp. Fifteen grams of this wet pulp were weighed out, suspended in 800 ml. of water, and beaten for 15 min. in a Waring Blendor. The product was diluted to the desired consistency and 1 liter poured into the sheetmold. After the water had run out, air was sucked through for 10 sec. and, if no displacing solvent was to be used, the sheet carefully couched between two blotting papers. A heavy brass cylindrical roll was used for pressing, the technique of rolling back and forth once being carefully standardized. If the water in the sheet were to be displaced, after the sheet had been placed under air suction for 10 sec., 50 ml. of liquid was carefully poured in, using a funnel in such a way that sheet formation was not disturbed. After standing for 1 min., air suction was again applied. If the liquid from which the sheet was to be finally dried, e.g., benzene, was immiscible in water, the water was first displaced by ethyl alcohol and a series of successive displacements used. After the water was thoroughly displaced by successive applications of solvent, the sheet was couched on to blotting paper and pressed in exactly the same manner as before.

By the development of a carefully controlled sheet making technique, it was possible to obtain handsheets $3^1/_2$ in. in diameter, in any desired number and weighing about 1 gram with a variation of about $\pm 0.04$ gram about the mean. For all cases studied at least 10 separate handsheets were made and the results shown in the tables are the averages for each such series. The degree of uniformity attained in any one series is

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illustrated by Table I which gives the individual values for such a series with benzene as the displacing liquid. In this way several series of handsheets were obtained

**Table I. Individual Results on Handsheets Dried from Benzene**

| | *Weight of handsheet, g.* | *Breaking strength, lb./in.* | *Elongation at break, %* | *Energy absorption capacity, in. lb.* |
|---|---|---|---|---|
| | 0.993 | 2.50 | 4.40 | 0.685 |
| | 0.952 | 2.10 | 4.40 | 0.572 |
| | 0.968 | 2.16 | 4.60 | 0.577 |
| | 0.964 | 2.31 | 3.80 | 0.515 |
| | 0.960 | 2.05 | 4.42 | 0.526 |
| | 0.995 | 1.94 | 4.28 | 0.483 |
| | 0.970 | 2.01 | 4.50 | 0.480 |
| | 1.014 | 2.30 | 3.95 | 0.544 |
| | 1.026 | 2.02 | 4.10 | 0.481 |
| | 0.993 | 2.55 | 5.08 | 0.784 |
| Av. | 0.984 | 2.19 | 4.35 | 0.565 |
| Standard deviation | 0.0236 | 0.201 | 0.343 | 0.0931 |
| Coefficient of variance, % | 2.4 | 9.2 | 7.9 | 16.5 |

made from the same furnish, beaten to the same degree; each series differing only in the liquid present during the drying of the sheets.

Drying was normally allowed to take place at 65% R.H. and 70°F., being the conditions of the relative humidity room. Two series were dried by sublimation by leaving in a cold box at −10°C. for 2 weeks, followed by withdrawal and conditioning in the relative humidity room at 65% R.H. and 70°F.

As in Part II all the stress-strain data presented in this paper were obtained on the Instron tensile testing machine, using a gage length of 2 in., sample width of

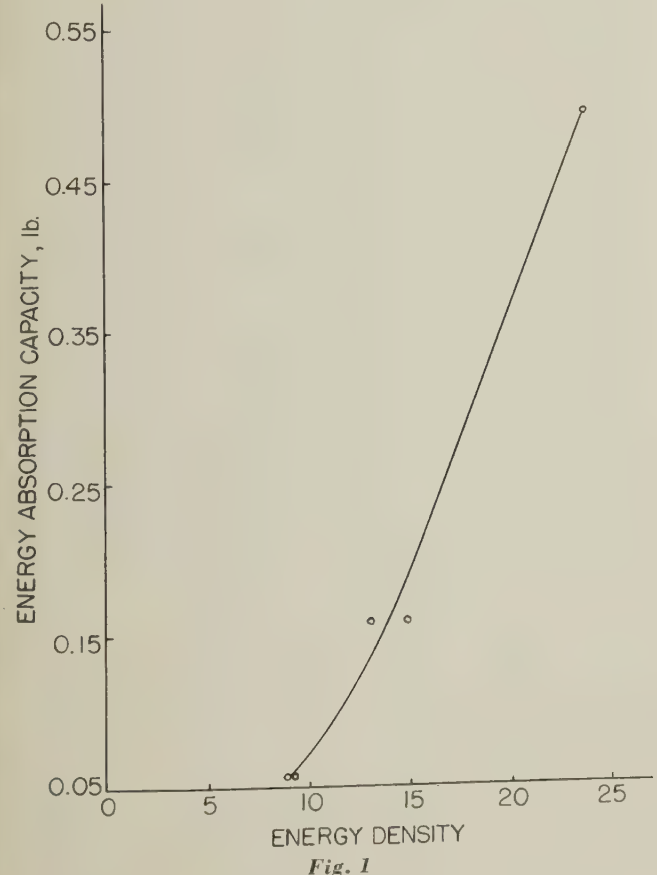


*Fig. 1*

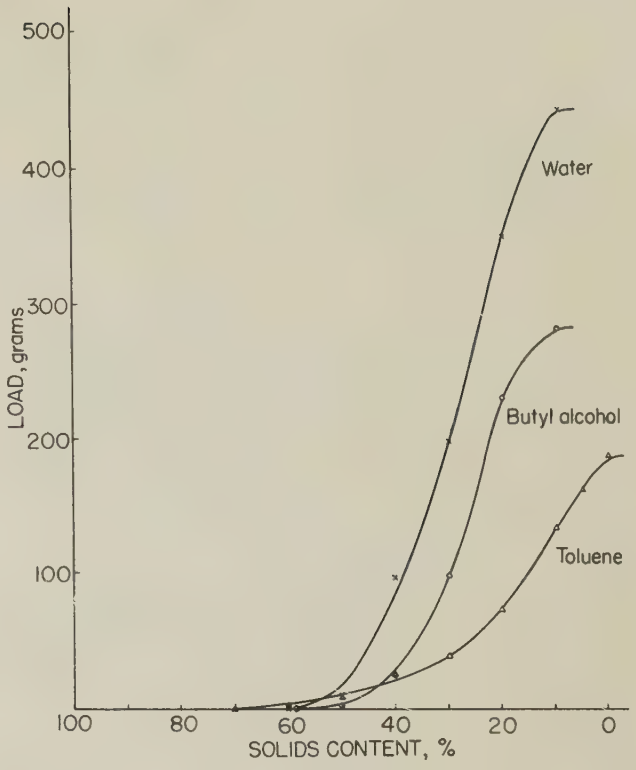


*Fig. 2*

3/8 in., and a cross-head speed of 0.2 in. per min. Ten samples were broken in each series and all jaw breaks were discarded. Chart magnification was 50×. Besides the simple break tests, cycling was carried out but only five runs were made in each series. The procedure followed in the cycling tests is shown in Table II.

The liquids used were of technical C.P. grade, their physical properties being listed in Table II of Part II of this series (*5*). In addition a nonionic surface active agent, Alrosol-C, kindly supplied by the Alrose Chemical Co., was used as a surface tension depressant yielding a solution with a surface tension of 30.3 dynes per cm. This solution was used as the liquid present during drying for one series of handsheets.

## DATA AND CALCULATIONS

From each stress-strain curve the breaking strength in pounds, the elongation at break in inches, and the energy absorption capacity to break in inch-pounds were obtained directly. These values were not corrected for handsheet weight since the differences are relatively small as compared with the major trends shown by the data.

From the cycling tests, the force required to produce 2% elongation in each of the three cycles was recorded, as were the energy absorptions corresponding to the first and second hysteresis loops. The strength and elongation at break and energy absorption capacity to break in the final cycle were also recorded.

**Table II. Cycling Test Procedure**

1. Extend the strip 0.04 in. (2% of initial length) at 0.2 in. per min. and retract at the same rate to zero load
2. Repeat operation 1
3. Repeat operation 1
4. Immediately re-extend the strip at 0.2 in. per min. to rupture

Table III. Curve Characteristics for Handsheets Dried with Various Liquids Present

| | Water | | | Water with Alrosol-C | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal drying | Freeze drying | Freeze drying | Normal drying | Freeze drying | Ethyl alcohol | Butyl alcohol | Benzene | Toluene |
| Surface tension liquid, dynes/cm. (70°F.) | 72.0 | .... | .... | 30.3 | .... | 21.3 | 26.2 | 28.9 | 30.2 |
| Handsheet weight, gram | 0.91 | 1.06 | 0.96 | 0.98 | 0.94 | 0.99 | 1.02 | 0.98 | 0.91 |
| Breaking strength, lb./in. | 9.58 | 7.69 | 7.02 | 6.42 | 4.58 | 4.44 | 4.96 | 2.19 | 2.00 |
| Elongation at break, % | 8.77 | 6.46 | 5.99 | 6.98 | 5.11 | 6.43 | 5.52 | 4.35 | 4.74 |
| Energy absorption capacity, in.-lb. | 0.496 | 0.269 | 0.244 | 0.267 | 0.134 | 0.157 | 0.159 | 0.057 | 0.056 |
| | 17.8 | 24.0 | 24.5 | 26 | 38.5 | 41 | 35 | 76 | 85 |

Table III shows the results obtained on the various handsheet series made with water, water with Alrosol-C (surface tension 30.3 dynes per cm.), ethyl alcohol, butyl alcohol, benzene, and toluene as the liquids present during drying. The corresponding cycling tests are shown in Table IV. Because the loops obtained in the second and third cycles were in all cases almost identical, only the energy absorptions corresponding to the first and second cycles are given.

It was noted at one point in the investigation that sheets formed in liquids of low polarity appeared to gain in strength on prolonged keeping. For this reason handsheets dried from butyl alcohol and toluene were allowed to stand in an atmosphere of 85% R.H. for varying times. Results are shown in Table V after bringing to 65% R.H. and 70°F. before testing. Because of the results shown there, the sheets used in the series of Tables III and IV were broken as soon as possible after equilibrium by conditioning at 65% R.H. and 70°F. was established.

One series of handsheets after drying from water was soaked in benzene in the manner described in Part II of this series (*5*) and the stress-strain curves determined. The results are given in Table VI.

## DISCUSSION

Study of the breaking strengths given in Table III brings out several interesting points. Assuming that the furnish and handsheet making procedure were identical in all cases, which is supported by the good checks obtained on duplicate series, reduction of surface tension during drying either by a surfactant or freeze drying results in large drops in sheet strength to 70 and 63%, respectively, of the value for the sheet made normally. When a surfactant and freeze drying are both used the breaking strength of the resultant handsheet is cut to 46% of that of the normal sheet; a somewhat surprising result, unless some further drying occurred after withdrawal of the sheet from the cold chest. If such were the case the surfactant present could lower the capillarity forces pulling the fibers together so that further bond formation during this period was inhibited or partially prevented. Thus, a still lower strength would be obtained than by sublimation drying alone. In any event the results confirm those of Van den Akker (*10*) and seem to support the view of Boyd-Campbell that surface tension pulls the contiguous fibers and fibrils into close contact during the drying of the sheet so that bonding can occur.

Capillarity forces can only be effective insofar as they bring the fibrils close enough together in an environment favorable to bonding. With toluene the sheet breaking strength is only 21% of that of a sheet made with pure water present during drying and only one third the strength of a sheet made with the water surfactant mixture having an identical surface tension. Clearly, assuming that the fibrils are pulled together to the same extent by liquids of equal surface tension, the environment of the fibers during bonding must be very important. This is confirmed by the intermediate position of the handsheet series dried from ethyl and butyl alcohols, which as discussed in Part II of this series, occupy as regards polarity, a position between water and the hydrocarbons. Presence of a nonpolar liquid during sheet drying is apparently more effective in prevention of bond formation than is wetting by the same liquid in destruction of the bonds (Table VI). While wetting by the nonpolar liquid does reduce the sheet strength considerably, it falls far short of lowering it to the level of the dry sheet produced by drying in presence of the same liquid. Furthermore, if the handsheet is wetted thoroughly by the nonpolar liquid and then allowed to dry, no considerable reduction in strength occurs (Table V of Part II). While nonpolar liquids can inhibit formation of the bonds, they cannot, unlike polar liquids, destroy them once formed. The bond forming capacity, as evidenced by breaking strength or energy absorption capacity at break, appears to be directly proportional to the energy density of the liquid present during drying (Fig. 1) while the bond destruction power of a wetting liquid on a paper is an inverse function of its energy density (Fig. 3 of Part II).

This suggests that in water, the hydroxyl groups of the cellulose chains comprising the surface of the fibril may well be oriented toward the water and hydrogen bonded to some of the water molecules. As drying progresses the surface tension forces, postulated by Boyd-Campbell, draw the fibrils together and some of

Table IV. Cycling Curve Characteristics for Handsheets Dried with Various Liquids Present

| | Water | | | Water with Alrosol-C | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Normal drying | Freeze drying | Freeze drying | Normal drying | Freeze drying | Ethyl alcohol | Butyl alcohol | Benzene | Toluene |
| Load at 2% elongation, lb./in. | 4.16 | 3.09 | 3.47 | 2.94 | 2.38 | 2.12 | 2.54 | 1.37 | 1.22 |
| Energy absorption, first cycle, lb. | 0.0282 | 0.0202 | 0.0249 | 0.0207 | 0.0178 | 0.0150 | 0.0178 | 0.0120 | 0.0094 |
| Energy absorption, second cycle, lb. | 0.0156 | 0.0158 | 0.0120 | 0.0108 | 0.0082 | 0.0080 | 0.0096 | 0.0053 | 0.0042 |
| Load at break, lb./in. | 10.83 | 7.73 | 7.79 | 6.10 | 4.80 | 4.47 | 5.90 | 2.18 | 2.27 |
| Elongation at break, % | 9.74 | 6.40 | 5.97 | 7.32 | 5.44 | 6.64 | 5.66 | 4.58 | 5.10 |
| Energy absorption capacity, in.-lb. | 0.587 | 0.259 | 0.248 | 0.257 | 0.149 | 0.171 | 0.156 | 0.058 | 0.064 |

Table V. Effect of Conditioning at 85% R.H. Handsheets Dried from Butyl Alcohol and Toluene

| | Butyl alcohol | | | Toluene | |
|---|---|---|---|---|---|
| | *Initial handsheet conditioned at 65% R.H. before testing* | *Conditioned at 85% R.H. for 1 day and then at 65% R.H. before testing* | *Conditioned at 85% R.H. for 7 days and then at 65% R.H. before testing* | *Initial handsheet conditioned at 65% R.H. before testing* | *Conditioned at 85% R.H. for 7 days and then at 65 % R.H. before testing* |
| Handsheet weight, grams | 1.37 | 1.17 | 1.17 | 0.91 | 0.91 |
| Breaking strength, lb./in. | 5.40 | 9.30 | 10.83 | 2.00 | 3.60 |
| Elongation at break, % | 5.9 | 7.5 | 8.0 | 4.74 | 6.03 |
| Energy absorption capacity, in.-lb. | 0.197 | 0.427 | 0.496 | 0.0562 | 0.126 |

the hydroxyl groups on adjacent fibrils may become close enough to hydrogen bridge with each other rather than with water molecules. As water is progressively withdrawn this occurs more and more frequently and finally the paper sheet, cross-linked by hydrogen bonds, is obtained. This process is interfered with either, if the fibrils are not brought as close together (freeze-drying or low surface tension), or if the orientation of the hydroxyl groups outwards toward the solution is lowered or suppressed. If the liquid is reduced in energy density or polarity, and is accordingly less likely to act as a proton acceptor or to form hydrogen bonds, then the surface hydroxyl groups will not orient outwards to the liquid to as great an extent. Fewer will be available for hydrogen bridging as the critical distance is reached during the drying process. As a consequence the number of cross-links per unit volume of the paper sheet will be reduced and its breaking strength and modulus be likewise lowered.

Table IV shows that decreasing loads are required to produce 2% elongation as the breaking strength drops, indicating progressively lower modulus of elasticity. Apparently no major differences in type of bonding occur as the water is substituted by other liquids or freeze-drying is used because the stress-strain cycle curves are similar in shape and differ only in their relative magnitudes. Thus, in all cases, the second and third cycles were almost identical and have an area of about one-half that of the first cycle loop (Table IV).

That no fundamental differences occur in the bonding process is also supported by a few experiments made in which the tension developed during drying was measured. A strip of the wet handsheet was placed between the jaws of the Instron tester in such a way that with 80% solvent content the instrument registered zero load but the strip was taut. The solvent was then allowed to evaporate under the room conditions of 65% R.H. and 70°F., the loss in weight of another identical strip exposed under identical conditions being meanwhile recorded. When the solvent content dropped to between 60 and 50%, the strip began to attempt to contract and tension was recorded on the Instron chart. The plot of load versus per cent solids content of the strip is shown in Fig. 2. The curve for water is similar to those obtained by Lyne and Gallay (*8*), the tension developing rapidly at about 55% solids and becoming substantially constant at 90% solids. The curves for butyl alcohol and toluene present during drying, while indicating less tension, show essentially similar shapes. This should again indicate that no fundamental differences in the bonding mechanism occur, only that fewer bonds are formed in butyl alcohol and toluene. The tensions developed during drying are not in the ratio of the breaking strengths of the handsheets allowed to dry freely without tension. Thus, the toluene handsheet (Table III) breaks at 2.00 lb. per in., the water handsheet at 9.58, a ratio of 0.21. The drying toluene handsheet, however, in spite of its lower surface tension, develops a tension 0.41 times that of the drying water handsheet suggesting that the bonding forces are extremely powerful even in the toluene formed sheet.

Table VI. Effect of Soaking a Handsheet Dried from Water in Benzene

| | *Dry handsheet* | *Soaked in benzene* |
|---|---|---|
| Breaking strength, lb./in. | 11.51 | 5.10 |
| Elongation at break, % | 9.75 | 8.23 |
| Energy absorption capacity, lb. | 0.645 | 0.255 |

The question arises, if a sheet has been formed from a nonpolar liquid in such a way that the maximum bonding power corresponding to the particular furnish used has not been realized, can additional bonds be formed without rewetting by liquid water or other polar solvents? The data of Table V indicate that exposure to high humidity does result, in the case of butyl alcohol dried sheets, in complete recovery of the potential strength present. The strength attained after 7 days' conditioning at 85% R.H. is as great as that of a sheet initially formed from water. With toluene dried sheets the process is much slower and was not followed to completion. Apparently the hydroxyl groups when the sheet is dried from a solvent other than water are oriented in such a way that in atmospheres of high relative humidity, they can reorient and bond between each other. It may be that this increase in bonding can occur only when capillary condensed moisture is present, such capillary condensation according to Barkas (*1*) occurs only at relative humidities of 65 to 70%. Further experiments following the increase in breaking strength of a butyl alcohol formed sheet when exposed for varying periods of time to relative humidities of 50, 60, 65, 70, and 85% would be of interest.

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# Application of Photographic Techniques in the Evaluation of Surface Smoothness and Coverage of Coated Papers

RUSSELL L. CLARK

**Surface smoothness and coverage are defined for the purposes of this paper. The various evaluation tools and techniques, other than phototechniques, useful in examining and assessing coverage and surface smoothness of coated papers are enumerated and briefly discussed. The merits and interpretive value of phototechniques are then presented.**

With the advent of coated papers, both conversion (off-machine) and on-machine coated, the printing industry was able to realize major printing quality improvements. Reproductions no longer were limited to the course 65 to 85 line screens employed in the printing of noncoated machine finish, English finish, and super grades. Reproduction with the finer 120, 133, and 150 line screens became a reality. Not only were improvements in reproduction made, but appearance gains were also realized. The coating of a fibrous web, however, was not the panacea for all of the printer's quality problems. Finer line screens exacted a paper quality and uniformity heretofore not required. Both the printing and paper industries have devoted considerable effort and research to the study of coated paper characteristics and their influence on (1) printing quality (i.e., printing fidelity), (2) printing tolerance, and (3) press operability.

Research efforts, in general, have established certain coated paper properties as essential for printing quality. These properties, enumerated without intent to weight them specifically, include: (1) surface smoothness, (2) coating coverage, (3) levelness, (4) cushion, and (5) ink receptivity. Encompassed in the term "cushion" are compressibility, recovery or resiliency, and bulk. Ink wettability is inclusive in the term "ink receptivity."

Two of the above-named properties, namely surface smoothness and coating coverage, are readily amenable to evaluation by photographic techniques. Such photographic techniques are the subject of this paper. Before proceeding with the merits, application, and discussion of these techniques, it is desirable first to (1) consider practical definitions of surface smoothness and coating coverage, and to (2) enumerate briefly the tools generally employed in the evaluation of these properties.

*Surface smoothness,* as applied to coated paper, is that degree of freedom from roughness which permits ink or other film contact to be made between the printing plate or blanket and the coated paper surface at normal printing pressures. Surface smoothness is a function of the minute deviations from planarity, such as the peaks and depressions of film split patterns normally associated with the physical application of coatings. This definition excludes gross deviations from planarity of the magnitude of $^1/_4$ in. or more in diameter, which are aspects of *levelness,* and are associated with raw stock formation, uniformity of caliper, etc. *Coating coverage,* the other property to be considered here, is the effective masking of rawstock fibers with coating pigments (by superficial treatment), such that the fiber components and their distribution are relatively invisible in the uncalendered or calendered surface.

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## EVALUATION OF SURFACE SMOOTHNESS AND COATING COVERAGE

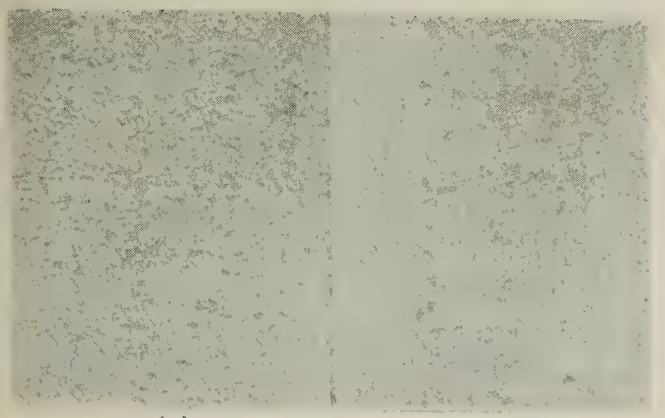
The customary tools for assessing surface smoothness and/or coating coverage are: (1) a hand lens in the order of 5 to 20 power magnification, (2) proofing techniques such as are practiced with a no. 4 Vandercook proof press, (3) a Brush surface analyzer or profilometer to chart a magnified profile of a paper surface, (4) Bekk smoothness—an air flow measurement, (5) Chapman smoothness—an optical measurement of light reflected diffusely and specularly from the lower surface of a prism in pressure contact with a coated paper surface, and (6) an R. R. Donnelley (Hull) draw-down technique which employs a flexible blade under light load to spread a partially thinned film of gravure ink.

These evaluation procedures are commonly accepted practices, with the possible exception of the Hull draw-down technique. The photographic techniques of this paper are not proposed as a replacement for any of the more common evaluation tools, but rather as a valuable supplement. The additional benefits derived from photographic techniques and the usefulness thereof will now be discussed.

### *Phototechniques*

*Advantages.* A camera is an optical instrument which, with selections of lens and extension bellows, makes possible the examination of a field much larger than can be viewed with a hand lens. Furthermore, a camera captures, without selective discrimination, all of the subject matter within its field of view, and is not subject to the human eye's habit of selective examination. It is admitted, of course, that the value of selectivity is not to be overlooked. In fact, it becomes an asset if it is a controlled practice. Controlled selectivity is possible by means of properly chosen illumination technique. Details of illumination will be discussed later in this paper. For the moment, it is sufficient to say that a differentiation may be made between surface smoothness and coating coverage if conditions of illumination are carefully chosen in order to favor one or other characteristic.

Photographic reproduction also offers a convenient



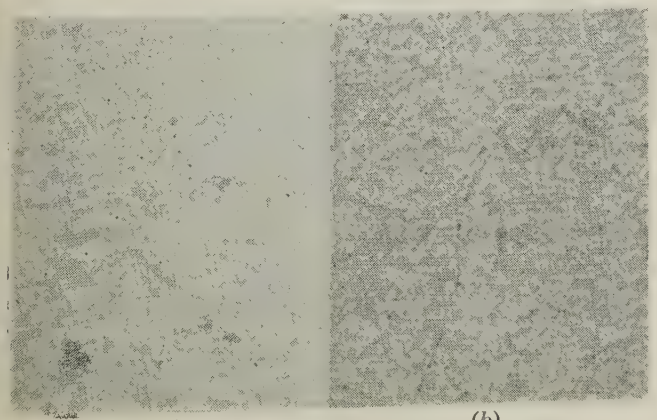
(*a*) (*b*)

*Fig. 1. Coverage—coat weight variable*

means for multiple viewing of a common subject. In other words, it makes possible the simultaneous examination of a coated surface by a number of interested observers, which in turn facilitates their arriving at an agreement on the pros and cons of the paper surface under study.

*Limitations.* It is only fair to cite a shortcoming of the proposed phototechniques—the fact that they are qualitative only. Quantitative or numerical ratings of photomicrographs of surface smoothness and coating coverage are not possible. Gradings must be subjective, but this handicap is not a serious one; rather, as experience in interpretation is gained, estimates can be made with ever increasing competence.

*Definitions of Photomacrography and Photomicrography.* The photographic techniques applicable in the evaluation of surface smoothness and coating coverage can be divided conveniently into photomacrographic and other photomicrographic techniques. Photomacrography—a subdivision of photomicrography—covers the very low range of magnification and is distinguished by the method by which the picture is made. For photomacrography, a simple microscope is used rather than the compound microscope. The simple microscope may be only a photographic lens, depending for its magnifying power on a bellows extension that is longer than the object-to-lens distance. Although there is an overlap of possible magnifications in the two methods, photomacrographs usually have a magnification of less than 25×, whereas photomicrographs involve a magnification of greater than 25×.



(*a*) (*b*)

*Fig. 2. Coverage—commercial samples*

(*a*) (*b*)

*Fig. 3. Coverage—wire side versus felt side*

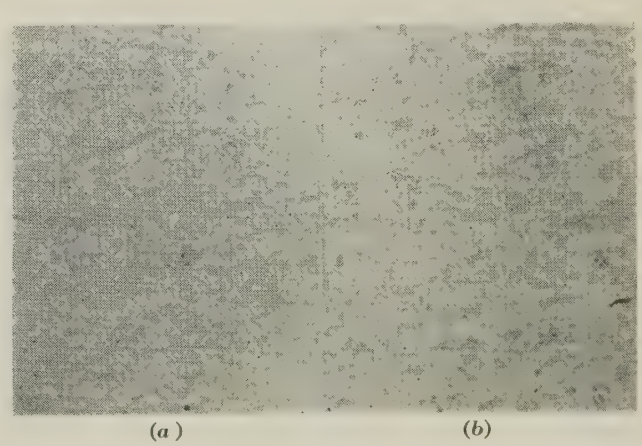
## PHOTOMACROGRAPHIC APPLICATIONS

Evaluation of surface smoothness and coating coverage by photomacrographic technique is the more direct method of the two. Reflected illumination is employed in this case. When studying coating coverage, 80° incident lighting is desirable. This illumination was determined to be the average practice among operators and research coating personnel of the Mead Corp. when viewing coated coverage with a low power hand lens. Surface smoothness, on the other hand, is more readily observed under illumination which produces greater shadow or greater contrast. After several attempts at mimicking lighting practices common in hand lens technique, it was found that the best photographic results were obtained with illumination at a grazing angle of 1 to 3° (i.e., 89 to 87° incident light). Under these latter conditions of lighting, whether it be observation with a hand lens or the analysis of a photomacrograph, there is a skill in observation that is essential for the successful interpretation of the shades and the contrasts that are photographically reproduced.

### *Coverage*

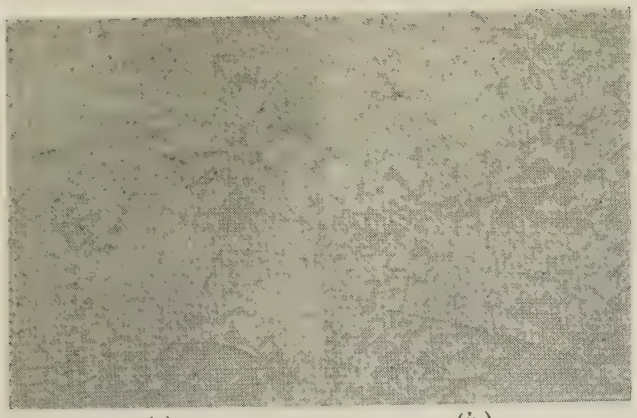
The first series of figures deal with coating coverage. The photographic exposure utilizes an 8.9 magnification. Printing was done by twofold enlargement; thus a 17.8 overall magnification. However, as viewed in opaque projection the magnification is nearly 650 to 700× (based on a 9 by 12-ft. projection on the screen).

Figure 1 is an example of two *equally* smooth surfaces



(*a*) (*b*)

*Fig. 4. Coverage—good versus poor rawstock*



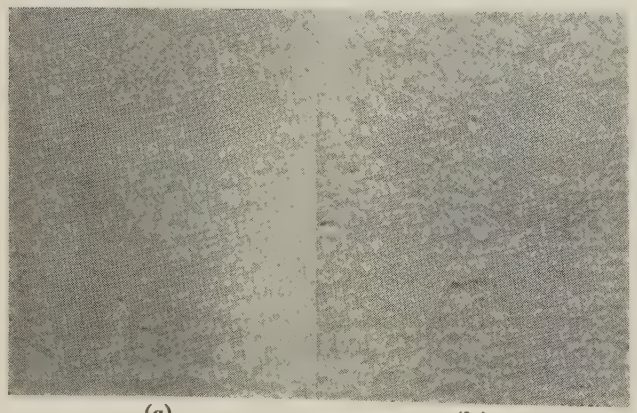
(a) (b)

*Fig. 5. Coverage—holdout versus penetration*

which exhibit differences in coating coverage as a function of coat weight. In order that complications from surface smoothness might be circumvented, applications of coating were accomplished by an acetate lamination technique followed by a normal hand calendering procedure. This special acetate lamination technique was the subject of a 1952 TAPPI Coating Conference paper presented by R. C. Hydell of the Mead Corp. In effect, the acetate lamination technique has provided a surface smoothness equivalent to that of cast coatings. Comparison of these equally smooth surfaces shows a preference for the coverage quality of Fig. 1a. Fiber coverage differences are quite evident. The coat weight difference in this comparison was $3^1/_4$ lb. ($6^1/_2$ to $9^3/_4$ lb.). By combining the acetate lamination technique with photomacrographic coverage evaluation, the coat weight demand of a specific rawstock may be accurately and easily established.

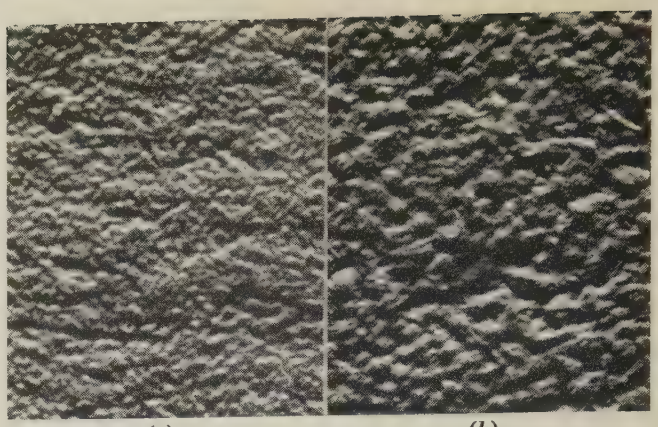
Figure 2 presents extremes in good and poor coating coverage. These samples are production grades, and are not laboratory preparations as in the first illustration.

Figure 3 illustrates wire side versus felt side coverage of a given rawstock at similar coat weight. Applications were by on-machine roll coating. The wire side displayed in Fig. 3a shows a moderate amount of fibrous character whereas the felt side, Fig. 3b, exhibits a greater number of barely covered fibers. Another indication of the more fibrous character and likewise poorer coverage of the felt side is the greater degree of blackening which resulted in the supercalendering operation.



(a) (b)

*Fig. 6. Coverage—calendering*



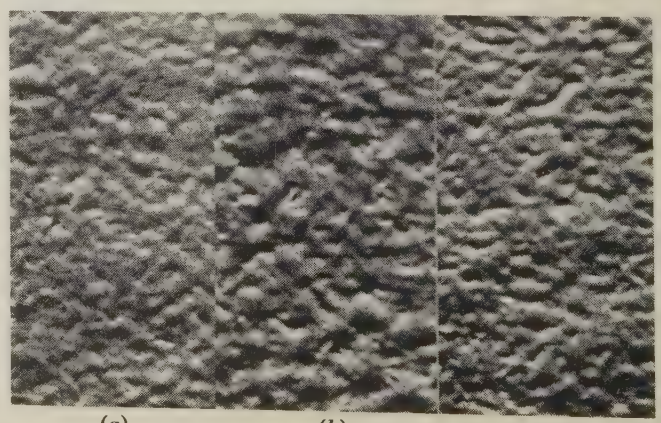
(a) (b)

*Fig. 7. Surface—film split patterns*

Figure 4 is a comparison in which the coverage differences were the result of good and poor rawstocks. The coat weight, choice of side coated, and method of application are the same for the two rawstocks. Calendering was conducted to nearly equivalent finish. Pronounced differences in coating coverage are readily discernible. Equivalent coverage of the poorer rawstock is possible mainly by increased coat weight application.

Figure 5 demonstrates coating "holdout" versus "penetration" resulting from coating formulation. Coat weight, rawstock, choice of side coated, and the method of application were the same in this comparison. It should be stated that in addition to formulation ingredients, coating color solids and viscosities were also variables. The color exhibiting "holdout," designated as Fig. 5a, is far less fibrous in quality of coverage than the example of "penetration," designated as Fig. 5b.

Figure 6 exhibits coverage differences as a function of calendering. This is an example of production samples that were identical prior to supercalendering. Frequently the calendering practice which is employed to achieve surface smoothness produces "crush" and fibrousness in the quality of coating coverage. Surface smoothness is essential for printing quality, but so is coverage which, in the case of fine particle coating pigments, produces better reproductions than do long, large diameter fibers. Thus, calendering practices generally have become a compromise between quality of surface smoothness and coating coverage with probably the greater emphasis being placed on surface smoothness.



(a) (b) (c)

*Fig. 8. Surface—pits*

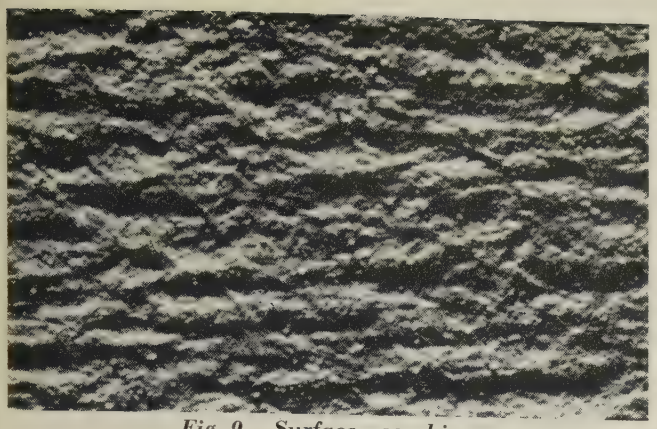
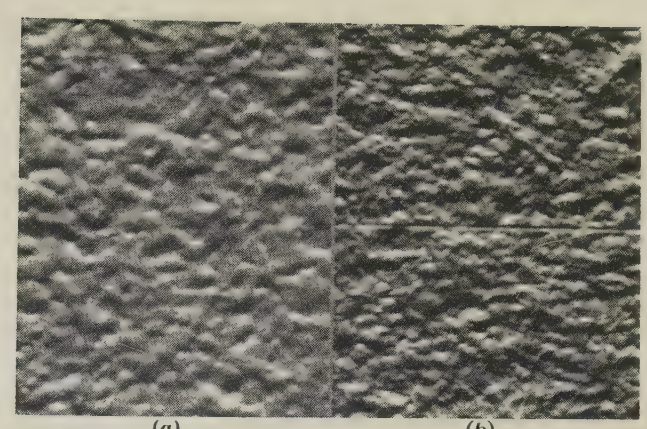


*Fig. 9. Surface—combing*



(a) (b)

*Fig. 11. Surface*

(a) Calender marking; (b) grit scratch.

***Surface Smoothness***

The next five illustrations present a few of the different kinds of surface deficiencies before considering the factors which influence the one specific surface deficiency which is probably the most important one—viz., film split pattern in roll coating.

Figure 7 illustrates an uncalendered surface pattern well known to on-machine roll coating operations which shall be referred to as a "film split pattern." Both a fine and a medium-coarse film split pattern are portrayed here. In the finer pattern, surface smoothness, only, is evident. In the medium-coarse pattern aspects of coating coverage can be discerned as well as the surface smoothness detail, even though 1 to 3° grazing illumination selectively accentuates surface smoothness.

Figure 8 presents a series of three calendered surfaces which exhibit "pits." The aspects of these pits differ in these three commercially produced grades. Figure 8c illustrates pits which are the result of a film split pattern which is relatively unyielding when supercalendered. Figure 8b shows pits that are primarily a result of rawstock soakiness and insufficient coating coverage. The pits of Fig. 8a are a combination result of film split pattern and fiber boundaries that do not yield in the supercalendering operation. Pittedness, whatever its cause, shows as unprinted spots in solids and tones printing. The squeeze of printing impression is usually not sufficient to make either partial or complete ink contact with the bottoms of the pits. Reproduction quality is therefore sacrificed, either for reason of the gross size or number of pits occurring in a printed area.

Figure 9 is an uncalendered illustration of "combing." This is a coating distribution defect that occurs in the machine direction, and is characteristic of coating transfer at light pressure. This defect is closely related to "ribbing," "beading," or narrow "banding."

Figure 10 is an example of improper minerals dispersion as seen in the uncalendered state. The minute grains which pepper the entire picture are evidence of poor coating color preparation.

Figure 11 shows markings and scratches. Figure 11a is an example of calender making of a coated surface which will print with fair quality, but which detracts from the quality of appearance. Figure 11b is an example of a grit scratch in the finished surface which occurred at the time of the coating application.

Figure 12 shows "pick-outs" that were experienced in offset printing. Figure 12a is a pick-out which resulted from the lifting of redeposited paper machine drier scale. Figure 12b, on the other hand, is a pick-out that resulted from the removal of a vessel segment by the high-tack, offset ink. The outlines and the characteristics of the bottoms of these pick-outs are different and serve to characterize their origin.

Selecting film split patterns as a specific surface deficiency of considerable importance, let us now consider the role of a few operating and application variables which are important thereto, and which are considered in the next few illustrations.

Figure 13 demonstrates the effect of coat weight as a variable on the quality of the film split pattern. All other aspects of application were constant. The transfer of a greater wet film thickness of the same color solids for purpose of improving coverage resulted in a

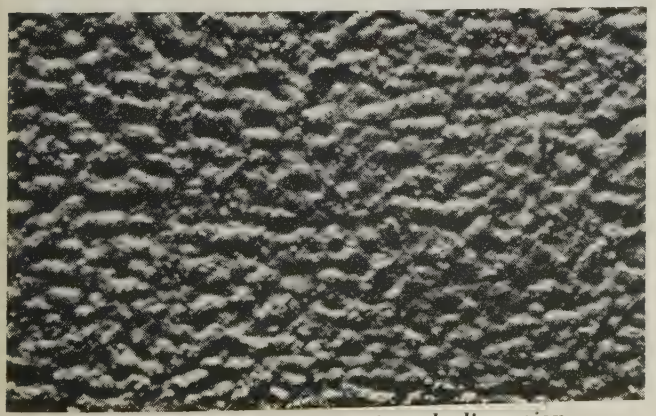
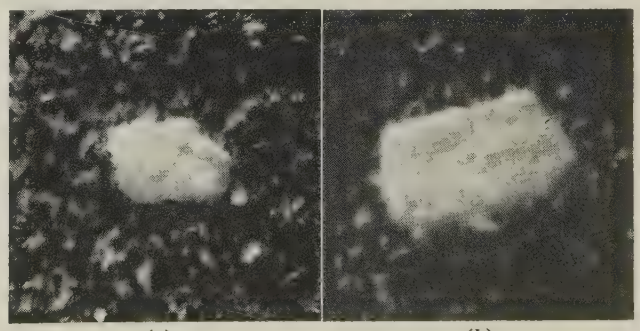


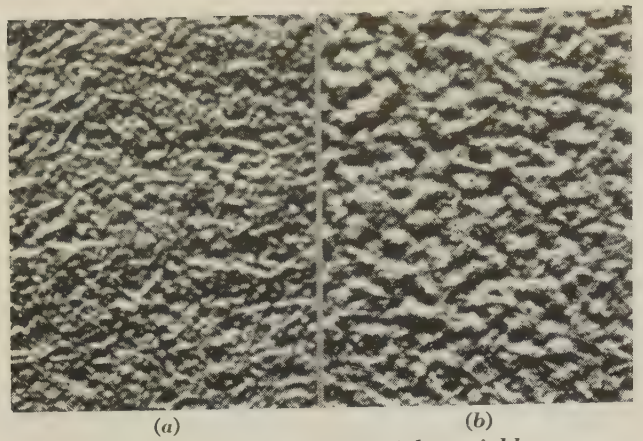
*Fig. 10. Surface—poor minerals dispersion*



(a) (b)

*Fig. 12. Surface—pick-outs from offset printing*

(a) Drier scale pick-out; (b) vessel segment pick-out.



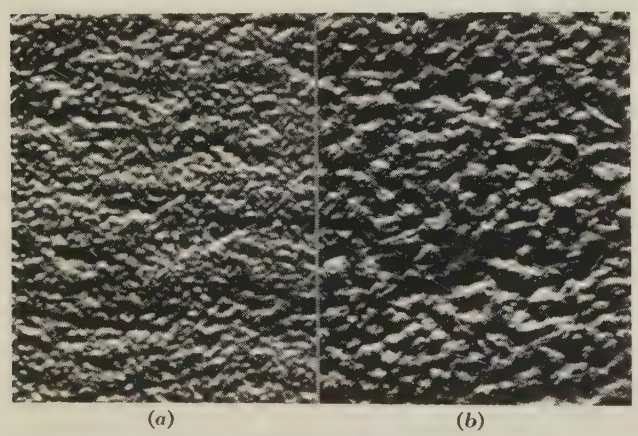
(*a*) (*b*)

*Fig. 13. Surface—coat weight variable*

more pronounced film split pattern. Consequently, when greater coat weights are desired for coverage or other reasons, the quality of film split pattern needs to be approached with formulation, process, and other variables.

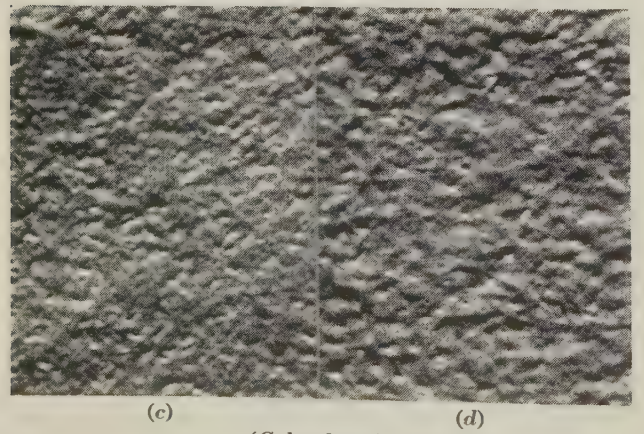
Figure 14 illustrates wire versus felt side film split patterns when conditions of rawstock, color formulation, coat weight and mode of application are maintained constant. Figures 14a and 14b show the uncalendered comparison. Figures 14c and 14d are the corresponding calendered comparison.

Figure 15 is a "good" versus "poor" rawstock comparison. This surface smoothness illustration is the counterpart of the coverage example previously discussed.



(*a*) (*b*)

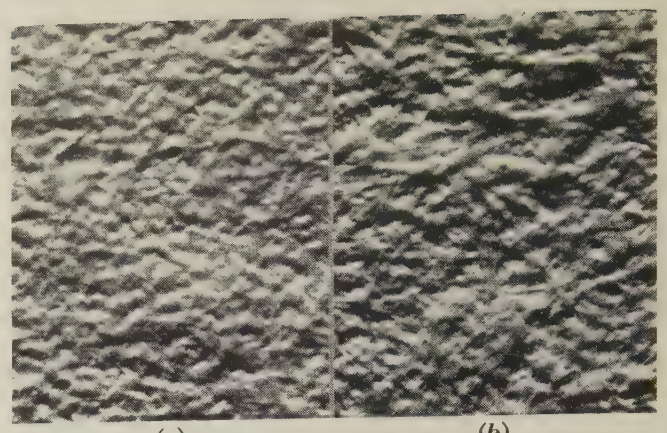
(*Uncalendered*)



(*c*) (*d*)

(*Calendered*)

*Fig. 14. Surface—wire side versus felt side*



(*a*) (*b*)

*Fig. 15. Surface—good versus poor rawstock*

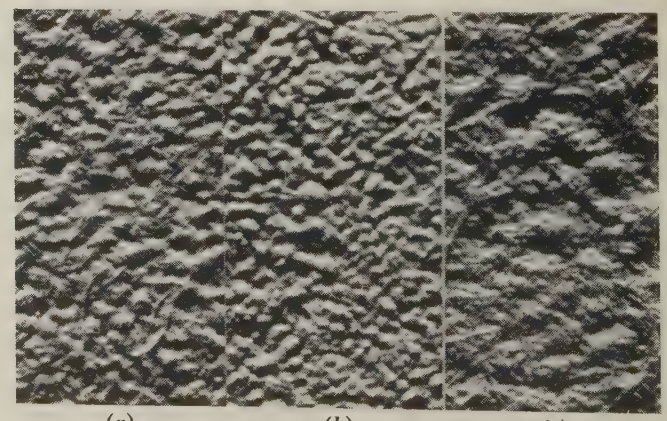
Figure 16 illustrates the potential of color formulation in altering film split patterns. Coat weights, rawstock, and application conditions were equivalent in this comparison.

Figure 17 illustrates the effect of supercalendering on a film split pattern. Figure 17a is the uncalendered surface, and Fig. 17b the calendered surface.

Figures 18a, 18b, and 18c are likewise a calendering comparison. Figure 18a is the uncalendered surface, Fig. 18b, the surface after calendering by a certain procedure, and Fig. 18c, the surface after calendering by a different procedure. The surface of Fig. 18c is the smoothest, and contains the least amount of pittedness. Figures 18d and 18e are the respective letterpress printed surfaces of Figs. 18b and 18c. The quality of printing in this comparison is closely related to surface smoothness. The clear white areas in the printed surfaces are pit defects where ink contact with the printing medium was not made. The gray areas may be a result of partially inked depressions or may be the high and dense points of the calendered film split pattern. In order to properly establish this defect, lens examination of the actual printed sample is necessary. The photographic reproduction does not differentiate clearly in this instance.

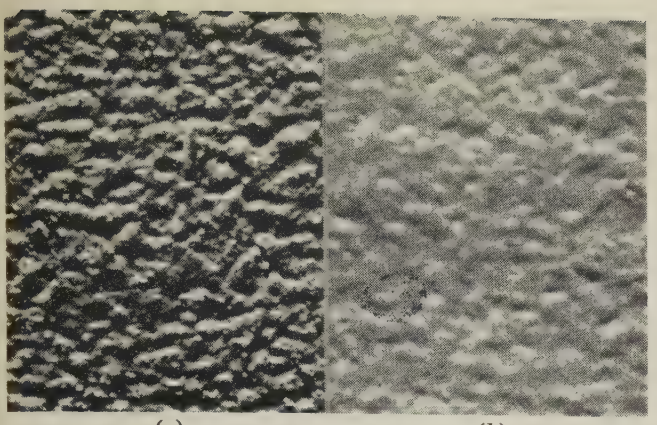
## PHOTOMACROGRAPHIC EQUIPMENT AND TECHNIQUES

The equipment used in the foregoing photomacrographic applications is relatively simple and is easily operated. The camera was a $3^1/_4$ by $4^1/_4$-in. Speed Graphic equipped with a Bausch and Lomb linen



(*a*) (*b*) (*c*)

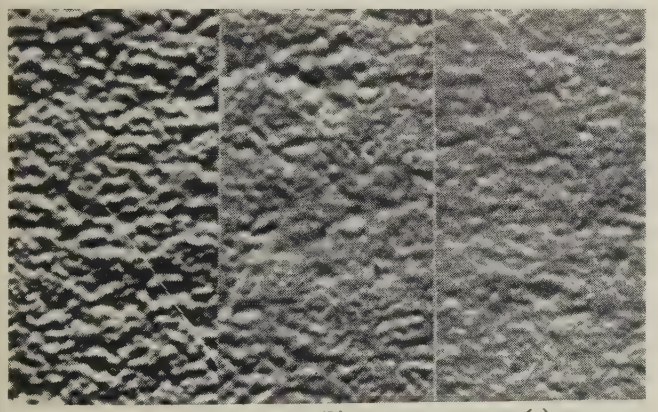
*Fig. 16. Surface—color formulation variable*



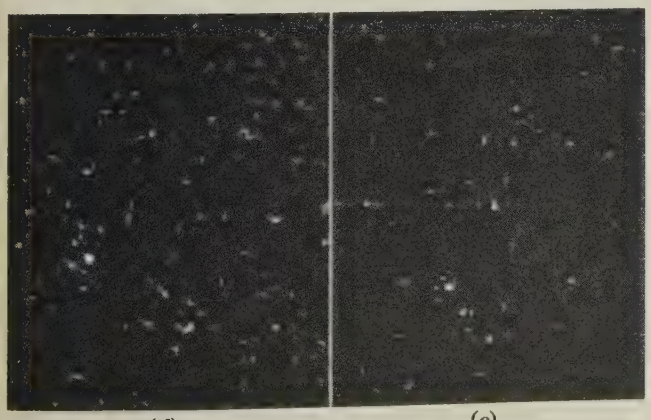
(a) (b)

*Fig. 17. Surface—calendering*

tester lens and a double extension bellows. This combination exposed an approximate $^1/_4$ by $^3/_8$-in. field with a resultant magnification of 8.9. A good lens with minimum of spherical correction is of paramount importance. For improvement in picture depth a Wratten A filter was employed in the surface smoothness exposures. This red filter eliminates or absorbs the wavelengths of the blue end of the spectrum, thereby effecting an increase in contrast and picture depth. Panchromatic Pan-X, a slow but fine grain film, has been found very satisfactory for this work. Flat mounting of coated samples with the simple medium of Scotch tape proved to be as good as more elaborate means such as vacuum mountings, etc. A Spencer



(a) (b) (c)



(d) (e)

*Fig. 18. Surface—calendering*

(a) Uncalendered surface; (b) calendered surface no. 1; (c) coated calendered surface no. 2; (d) letterpress printing surface no. 1; (e) letterpress printing surface no. 2.

microscope lamp with diaphragm closed down to a 30 setting and focused properly, served as the light source. Coating coverage exposures were at f32 for maximum depth of field. Surface studies were more conveniently exposed at f22. To facilitate and guarantee the reproducibility of these photomacrographic procedures a rig and camera mount was adopted. Figures 19a and 19b illustrate a simple rig and camera mount with which Mead Corp. research conducted its first photomacrographic work in the study of surface

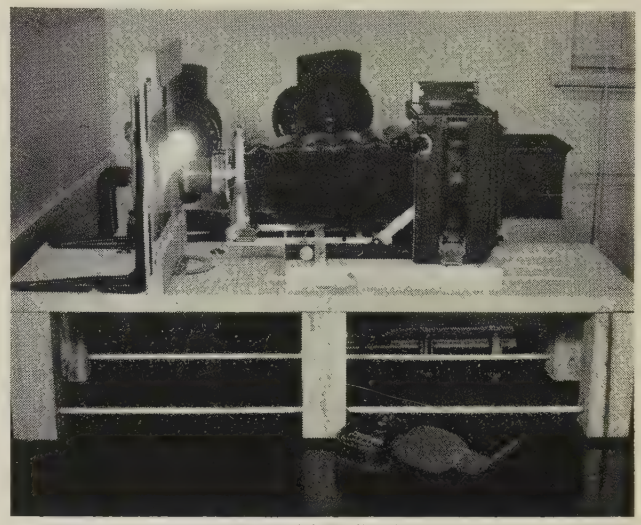


*Fig. 19 (a). Surface*

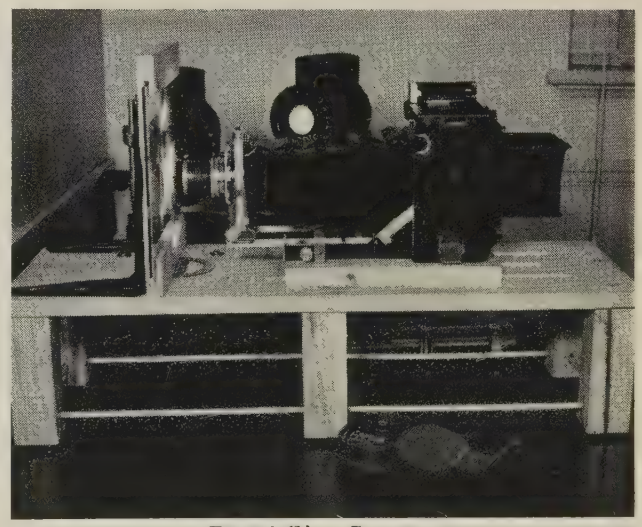
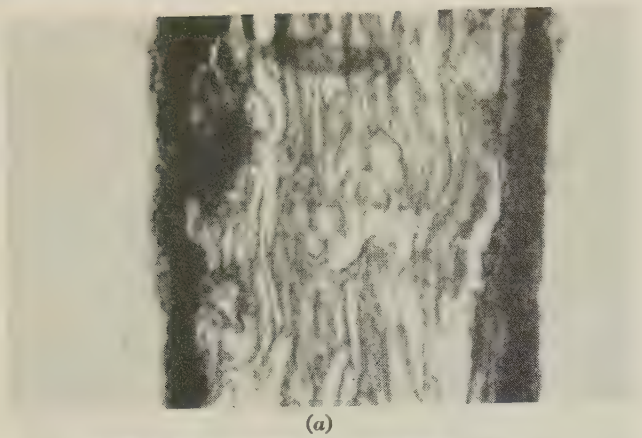


*Fig. 19 (b). Coverage*

smoothness and coating coverage of coated papers. Refinements have since been added. Film development has been standardized with Eastman chemicals, and the developing time standardized at 0.9 gamma. Potentials still in the idea and development stage which may add to the value of these techniques include the use of (1) black light illumination (ultraviolet) in conjunction with color film, and (2) a stereomicroscope to produce photographs which can be viewed in "3D." Observance of standard photographic practices plus a careful and representative sampling of coated samples is all that is required to produce the macrophotographs previously described. An estimated $500 will provide the essential equipment and chemicals to initiate this photomacrographic work. Man-hour-wise, with a



(a)

(b)

*Fig. 20. Coated paper microsections*

fair background of experience, one person should be able to select, mount, photograph for both coating coverage and surface smoothness, and develop film for approximately 12 to 14 samples in an average 8-hr. working day. Printing by enlargement is a relatively fast process and seldom requires more than a half day for each single day's processing time prior to printing. These expense and manpower requirements represent very little compared to the value gained from macrophotographic study.

## OTHER PHOTOMICROGRAPHIC APPLICATIONS

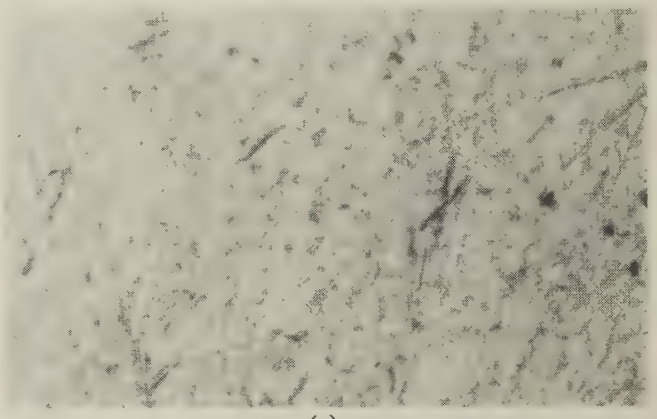
Photomicrographic applications in the evaluation of surface smoothness and coating coverage at magnifications greater than 25× are less numerous than the foregoing photomacrographic applications. They are less direct in their evaluation approach, and are more elaborate in technique, equipment costs, and manpower requirements. Conventional photomicrographic equipment and procedures are employed. Illumination is accomplished with transmitted light.

Coating distribution on and within a rawstock is amenable to study by means of microsection techniques. Figure 20 shows two such microsections which serve to illustrate varying degrees of coverage. These microsections are of the "good" and "poor" rawstocks which were discussed in the previous illustrations on coating coverage and surface smoothness (Figs. 4 and 15 respectively).

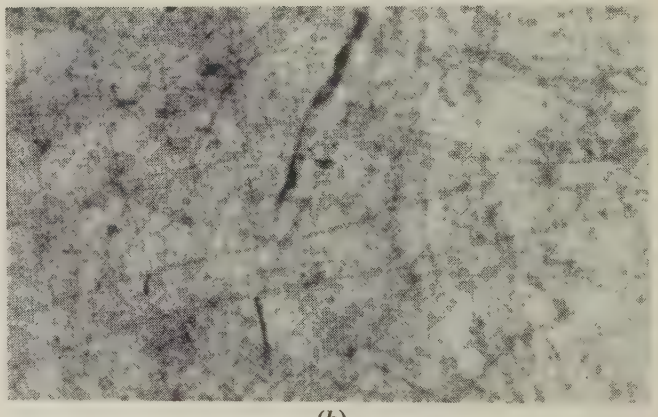
Figure 21 (a and b) compares rawstocks of different filler content and filler distribution. Clove oil saturation of the rawstock samples served to transparentize the fibers and present the filler for consideration. Figures 21c and 21d display the surface smoothness and to some extent the coating coverage comparisons of these two rawstocks of different filler content and distribution.

Figure 22 (a and b) is a fiber species and refining comparison of the "good" and "poor" rawstocks discussed in Figs. 4, 15, and 20. Fiber species and refining play an important role in the quality of coating coverage and surface smoothness. The coated samples were carefully pulped and the fibers separated from coating and filler by means of 300 mesh screening. These fiber furnishes were then prepared according to the standardized procedures of fiber microscopy.

Of the many observations thus far suggested that relate the importance of rawstock to coated paper quality, one very important property has yet to be mentioned. This property is rawstock formation. Unfortunately, this variable is not readily amenable

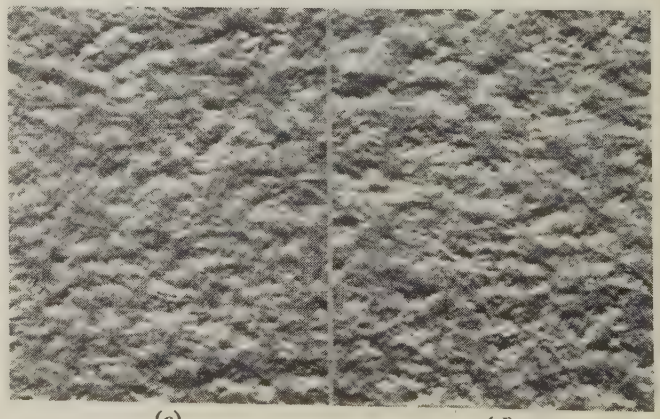


(a)



(b)

*Filler studies*



(c) (d)

*Fig. 21. Surface—filler variable*

to photographic evaluation. However, there are other means by which formations can be evaluated. Thus, for the sake of completeness in this study of "good" and "poor" rawstocks, the respective formations are illustrated by Fig. 23. This projection relates to an R. R. Donnelley draw-down technique accomplished by the spreading of an ink film with a weighted, blunt-edged knife. The role of fiber species, refining, and formation of rawstock have thus been considered in conjunction with the qualities of coating coverage and surface smoothness as obtained from a specific coating formulation and by a specific means of application (process).

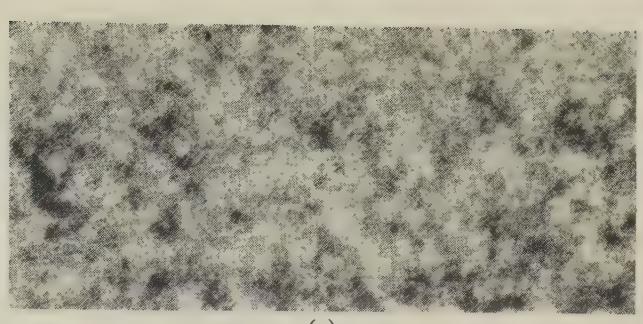
## PHOTOMICROGRAPHIC EQUIPMENT AND TECHNIQUES

Photomicrographic equipment briefly enumerated includes: (1) a microscope; (2) a photomicrographic camera, (3) a microtome, (4) a suitable light source, and (5) miscellaneous accessories. An estimated $4000 to $5000 will cover the essentials for this type of work. Techniques involved are the standard procedures of photomicrography, microsectioning, and fiber microscopy. Considerable skill and time are requisites for successful results. Comparing the costs, skills, and time requirements for accomplishing the photomacrographic and photomicrographic techniques of this paper, a ratio of 1 to 10 can be approximated. Thus, a photomacrographic program, which certainly provides useful data, is not a formidable practice. It is only in the case of more detailed research that the more elaborate photomicrographic work becomes attractive.

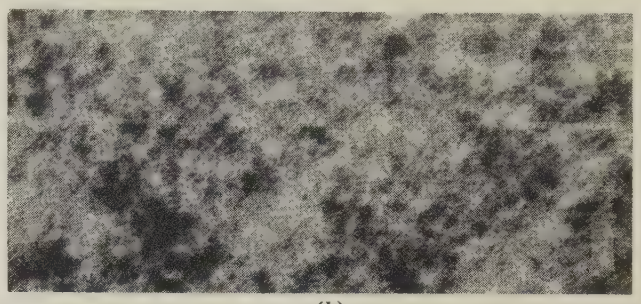
(*a*)

(*b*)

***Fig. 22. Fiber species and refining***



(*a*)



(*b*)

***Fig. 23. Formation by Hull drawdown***

These photomacrographic and photomicrographic evaluation tools have been considered from the viewpoints of (1) *what* applications are possible in the study of surface smoothness and coating coverage, (2) *how* these applications are accomplished, and (3) to some extent *why* these applications are valuable. But, in closing, a brief consideration is given to *where* these applications are valuable and practical.

The opportunities for usefulness as a research tool are excellent for both photomacrographic and photomicrographic applications. As a technical service tool, only the photomacrographic applications would be practical, and then only in limited instances. However, in sales service work, particularly in the analysis of customer complaints, the possibilities for photomacrographic applications are numerous. Photomicrographic applications would be very limited and would perhaps be better suited to a research function in a sales service capacity for reason of the elaborate equipment and techniques involved. The remaining opportunity for the photomacrographic evaluations medium is in operations control. As illustrated throughout this paper, photomacrographs of coated surfaces offer an important training and reference medium for operations and inspection personnel. However, the time and photographic ability required preclude any large scale use of these techniques. Thus a "short-cut" to the same macrographic end result is needed before this tool becomes really attractive in operations control. Such a "short-cut" is not entirely a pipe dream. An opaque or reflection-type projector can be designed which would employ the 20° and 1 to 3° illuminations of the respective surface smoothness and coverage techniques, and which in itself would serve the function of a simple microscope, as does the camera in photomacrographic applications.

PRESENTED at the Fifth Coating Conference of the Technical Association of the Pulp and Paper Industry, Poland Spring, Me., May 24–26, 1954.

Acknowledgments are made to Emerson L. Scott of the Mead Research staff for the development of the photomacrographic and photomicrographic techniques as practiced by Mead Corp. Research and to Frank Lee, also of Mead Research, for the preparation of projection and display material used in this paper.

# The Selection of Chipper Drives*

M. J. OSBORNE

**The Electrical Engineering Committee of TAPPI created a subcommittee at the Sixth Engineering Conference in Savannah, Ga., and gave it the responsibility of arriving at power requirements for chipping various species of wood and for developing nomographs, formulas, and other tools which will be useful in the selection of the proper induction or synchronous motor drives. The committee has tabulated data from 34 chipper installations. These tables showed that there were appreciable variations in the power required for chipping, and more important than these power differences is the complete lack of consistency in methods of motor application both as to type and rating. Recommendations have been made as to the proper power constants to be used for chipping the various species of wood. Seven horsepower-hours per cord should be used to determine motor sizes for chipping "soft" woods; 10 hp.-hr. should be used for chipping "hard" woods. Two different systems of motor selections have been developed, checked, and approved for presentation to TAPPI. Both of these systems will be made into Data Sheets.**

## POWER REQUIREMENTS

GROUP I of the committee recommendations includes fir and southern pine, ranging in shear stress parallel to the grain of 690 to 1350 lb. per sq. in. There were 29 power readings for this group. The average, minimum, and maximum readings were as follows:

| | |
|---|---|
| Average | 6.9 hp.-hr. per cord |
| Minimum | 4.1 hp.-hr. per cord |
| Maximum | 9.7 hp.-hr. per cord |

The committee suggests that a TAPPI recommended practice of 7 hp.-hr. per cord be adopted to cover the requirements of this group.

These woods were considered as "soft" woods. Motor ratings selected on the basis of 7 hp.-hr. per cord with the service factor of 115% would provide a capacity of 8.1 hp.-hr. per cord, which covers more than 75% of the 29 power readings of the group.

Group II of the recommendations includes gum and locust, commonly classified as "hard" woods, ranging in shear stress parallel to the grain of 1490 to 2100 lb. per sq. in.

There were only five power readings for this group. The average, minimum, and maximum readings for this group were as follows:

| | |
|---|---|
| Average | 8.6 hp.-hr. per cord |
| Minimum | 7.7 hp.-hr. per cord |
| maximum | 10.5 hp.-hr. per cord |

The committee sugests that a TAPPI recommended practice of 10 hp.-hr. per cord be adopted to cover the requirements of this group. It will be noted that motor ratings selected on the basis of 10 hp.-hr. per cord will cover all of the power readings reported.

## DATA COLLECTION

The committee has done everything it can to obtain a significant quantity of power readings for chipping all wood species. When there has been an error in the data, as for example, when the reported power consumption is for the entire woodroom rather than for the chipper motor alone, this fact was reported to the mill and an effort was made by the entire committee to as-

M. J. OSBORNE, Bowaters Southern Paper Corp., Calhoun, Tenn.; Chairman, Chipper Drive Subcommittee of TAPPI.

* Chipper Drive Subcommittee report (TAPPI Project no. 433).

**Table I. Tabulation of Horsepower-Hours per Cord for Various Wood Species**

| *Specie* | *Shear stress, lb./sq. in.* | *Recommended hp.-hr./cord* |
|---|---|---|
| Fir | 690 | 7 |
| Balsam | 690 | |
| Aspen | 800 | |
| Spruce | 950 | |
| Poplar | 980 | |
| Pine—northern | 800/1040 | |
| Hemlock | 1010/1060 | |
| Larch | 1200 | |
| Pine—southern | 1180/1350 | |
| Gum | 1490 | 10 |
| Maple | 1610 | |
| Oak | 1700 | |
| Birch | 1725 | |
| Hickory | 1870 | |
| Locust | 2100 | |

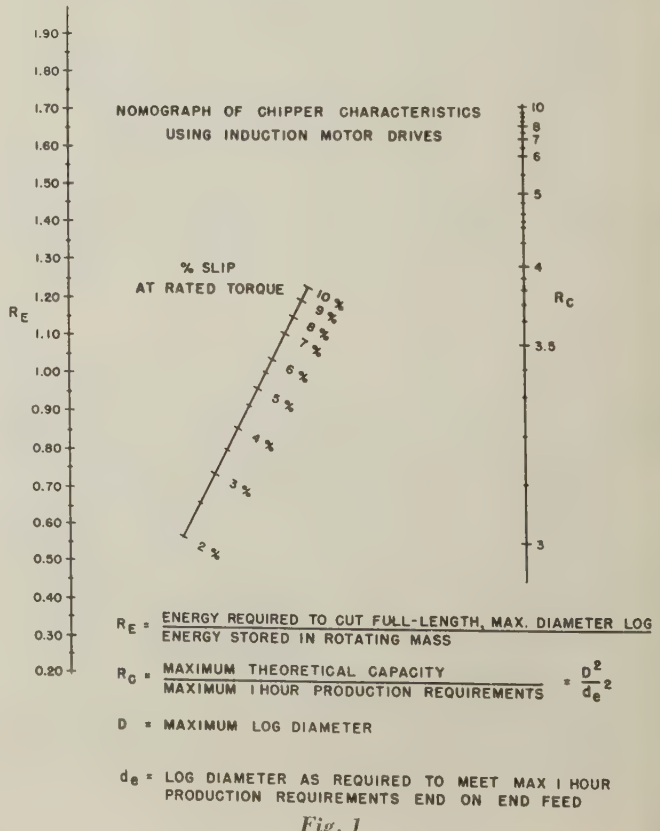

NOMOGRAPH OF CHIPPER CHARACTERISTICS
USING INDUCTION MOTOR DRIVES
% SLIP
AT RATED TORQUE
$R_E$
$R_C$
$R_E$ = ENERGY REQUIRED TO CUT FULL-LENGTH, MAX. DIAMETER LOG / ENERGY STORED IN ROTATING MASS
$R_C$ = MAXIMUM THEORETICAL CAPACITY / MAXIMUM 1 HOUR PRODUCTION REQUIREMENTS = $D^2/d_e^2$
D = MAXIMUM LOG DIAMETER
$d_e$ = LOG DIAMETER AS REQUIRED TO MEET MAX 1 HOUR PRODUCTION REQUIREMENTS END ON END FEED

*Fig. 1*

sist in providing instrumentation or service men to obtain correct information. Some mills have gone to considerable trouble and expense in providing laboratory-type tests; the logs were measured at both ends, carefully counted, and the power requirements for each log computed. These data are very valuable.

These records are being turned over to the secretary of the Electrical Engineering Committee and will become a part of that permanent file.

### MOTOR SELECTION

R. R. Baker and G. E. Shaad have developed two systems for motor selection. Mr. Baker's system is referred to as system no. 1, and Mr. Shaad's system as system no. 2. The committee feels that mill engineers can use either or both of these procedures according to their desires. Mr. Baker's procedure uses formulas and in the case of induction motors, one nomograph. Mr. Shaad's system is essentially a nomographic solution and offers a check within the calculation form for induction motors.

Some engineers prefer the use of a single formula wherein all of the factors are inserted. A single formula can be used for synchronous motors:

$$\text{h.p.} = \frac{SND^2LK \times 0.4}{3100}$$

where

$N$ = number of knives
$S$ = revolutions per minute
$D$ = maximum log diameter (inches)
$L$ = length of chip (inches)
$K$ = horsepower-hours per cord

The committee was guided by the chipper manufacturer and set a maximum slow-down of 25% (minimum speed of 75%) for wound rotor motors. This corresponds to a full load slip of 5%. The procedure for system no. 1 was set up for a maximum full load slip of 5%, but the nomograph is designed so that any slip can

**Chipper Drive Selection—System No. 1**

Sect. I-A—Normal production = ____ cords/hr.
B—Maximum 1 hr. production = ____ cords/hr.
C—Wood species = ____
D—Maximum log length = ____ ft.
E—Average log diameter = ____ in.
F—Disk diameter = ____ in.
G—Spout diameter = ____ in.
H—Total $WR^2$ (disk, sheaves, and other) = ____ lb./sq. ft.
J—Maximum chipper speed = ____ r.p.m.
K—Number of chipper knives = ____
L—Maximum chip length = ____ in.
M—Method of removing chips = ____

Sect. II-A—Horsepower-hours per cord (from Table I) = ____ hp.-hr./cord

B—Chipper feed $= \dfrac{\text{chipper r.p.m.} \times \text{no. of knives} \times \text{chip length}}{12} = \dfrac{(IJ) \times (IK) \times (IL)}{12}$ = ____ f.p.m.

C—Maximum log diameter $D$ = spout − 2 = $IG - 2$ in. = ____ in.

D—Maximum theoretical chipper capacity = feed × 0.00385 × $D^2$ = $IIB \times 0.00385 \times IIC^2$ = ____ cords/hr.

E—Peak power demand = hp.-hr./cord × maximum theoretical capacity = $IIA \times IID$ = ____ hp.

F—Chipper capacity ratio = $R_c = \dfrac{\text{maximum theoretical capacity}}{\text{maximum 1 hr. prod. requirements}} = \dfrac{IID}{IB}$ = ____ $R_c$

G—Cords per log, maximum permissible diameter full length $= \dfrac{\text{log length} \times D^2}{15{,}600} = \dfrac{ID \times IIC^2}{15{,}600}$ = ____ cords/log

H—Energy required to chip 1 log maximum diameter and full length in horsepower seconds = hp.-hr./cord × cords/log × 3600 = $IIA \times IIG \times 3600$ = ____ hp.-sec.

J—Stored energy $= \dfrac{WR^2 \times \text{r.p.m.}^2}{3.2 \times 10^6} = \dfrac{IH \times IJ^2}{3.2 \times 10^6}$ = ____ hp.-sec.

K—Energy ratio ($R_e$) $= \dfrac{\text{energy to chip maximum full length log}}{\text{stored energy}} = \dfrac{IIH}{IIJ}$ = ____ $R_e$

Sect. III-A—Peak power demand when chipping log of maximum diameter $D$ = theoretical chipper capacity × hp.-hr./cord = item $IIE$ = ____ hp.

B—$R_c$ = item $IIF = \dfrac{\text{maximum theoretical capacity}}{\text{maximum 1-hr. production requirements}}$ = ____ capacity ratio

C—Where $R_c \leqq 2.5$ select synchronous motor rating $\leqq \dfrac{\text{item } IIE}{2.5}$ = ____ hp.

D—Where $R_c < 2.5$ select synchronous motor rating ≧ hp.-hr./cord × maximum 1 hr. production = $IIA \times IB$ = ____ hp.

Sect. IV —For all induction motor applications the ratings should not be less than the thermal rating:
Horsepower = hp.-hr./cord × maximum 1 hr. production = $IIA \times IB$ = ____ hp.

A—Energy ratio ($R_e$) $= \dfrac{\text{work}}{\text{stored energy}} = IIK$ = ____ $R_e$

B—Capacity ratio ($R_c$) = $IIF$ = ____ $R_c$
C—Establish slip from nomograph (Fig. 1) = ____ %
D—Capacity ratio $(R_c)_1$[a] = ____ $R_{c1}$
E—If slip ($IVC$) is between 2 and 5% select motor rating h.p. = $IIA \times IB$ = ____ hp.
F—If slip > 5% select wound rotor rating hp. = $IIE/R_{c1}$ = ____ hp.
G—Check average diameter of mill logs against end-on-end diameter calculated by formula:

$$D_e = \sqrt{\frac{IB}{IIB \times 0.00385}}$$ = ____ in.

If $D_e$ is less than average mill diameter log ($IE$) multiply motor rating by $IE/D_e$ and use larger motor.

[a] $(R_c)_1$ = $R_c$ equivalent 5% for established value of $R_e$.
*Note:* All synchronous motors are assumed as 250% pull-out torque, all induction motors 250% breakdown torque.

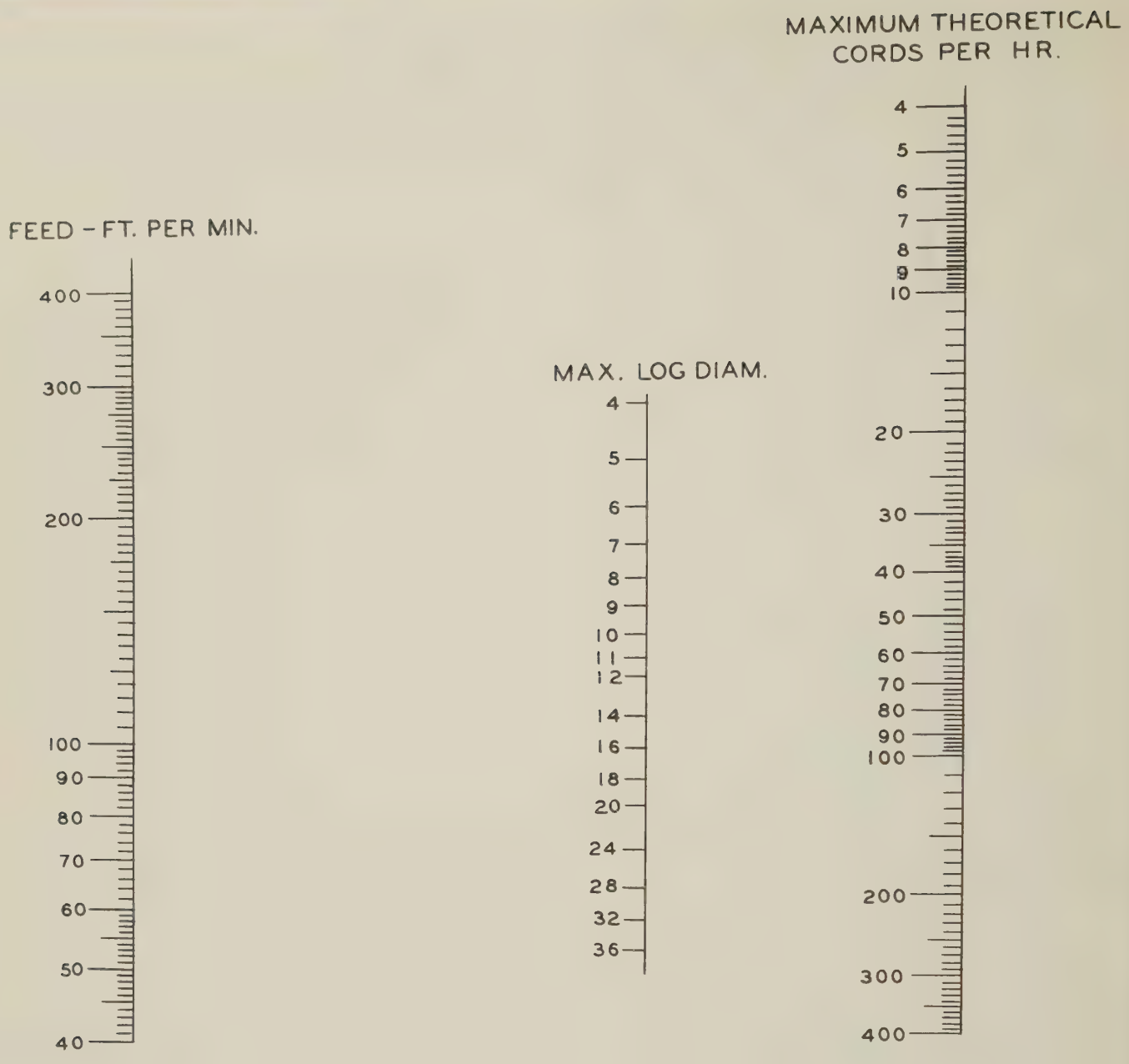



*Fig. 2*

be selected that is desired. Slip at breakdown occurs at five times rated load slip. There are many chipper installations where wound rotor motors were purchased for 10% slip at rated load with permanent grid resistors inserted in the rotor circuits. There are many that run with 6 to 8% slip at rated load.

***Example Using System No. 1***

To illustrate the recommended procedure in system no. 1 for selecting either synchronous or induction motor ratings, let us take a typical example:

II. E. Peak power demand – 2230 hp.
F. Chipper capacity ratio ($R_c$) = 6
K. Energy ratio ($R_e$) = 0.70
III. C. $R_e > 2.5$ 900-hp. motor
Synchronous motor rating
IV. C. Slip from nomograph (Fig. 1) 7%
D. Induction motor rating—374 hp. (7% slip) 400-hp. motor
F. Induction motor rating
5% slip $(R_c)_1 = 4.2$
530 hp. 600-hp. motor

**Chipper Drive Selection—System No. 2**

Chipper Calculation Form—Synchronous Motor

1. Chipper revolutions per minute = ____.
2. Number of chipper knives = ____.
3. Chip size = ____ in.
4. Feed in feet per minute = r.p.m. × knives × chip length, in. × 12 = ____.
5. Maximum log diameter ____ (spout diameter minus 2 in.).
6. Maximum theoretical cords per hour (Fig. 2) = ____.
7. Horsepower-hours per cord (selected in accordance with wood species) = ____.
8. Nominal horsepower (Fig. 3) = ____.
9. Capacity ratio = $\frac{\text{maximum theoretical cords per hour}}{\text{maximum production rate (1 hr. peak production)}}$.
10. Thermal horsepower demand (Fig. 3) = ____.
Required motor size is the larger of the values obtained in line 8 or line 10 = ____.

Chipper Calculation Form—Induction Motor

1. Chipper revolutions per minute (synchronous speed) = ____.
2. Number of chipper knives = ____.
3. Chip size = ____ in.

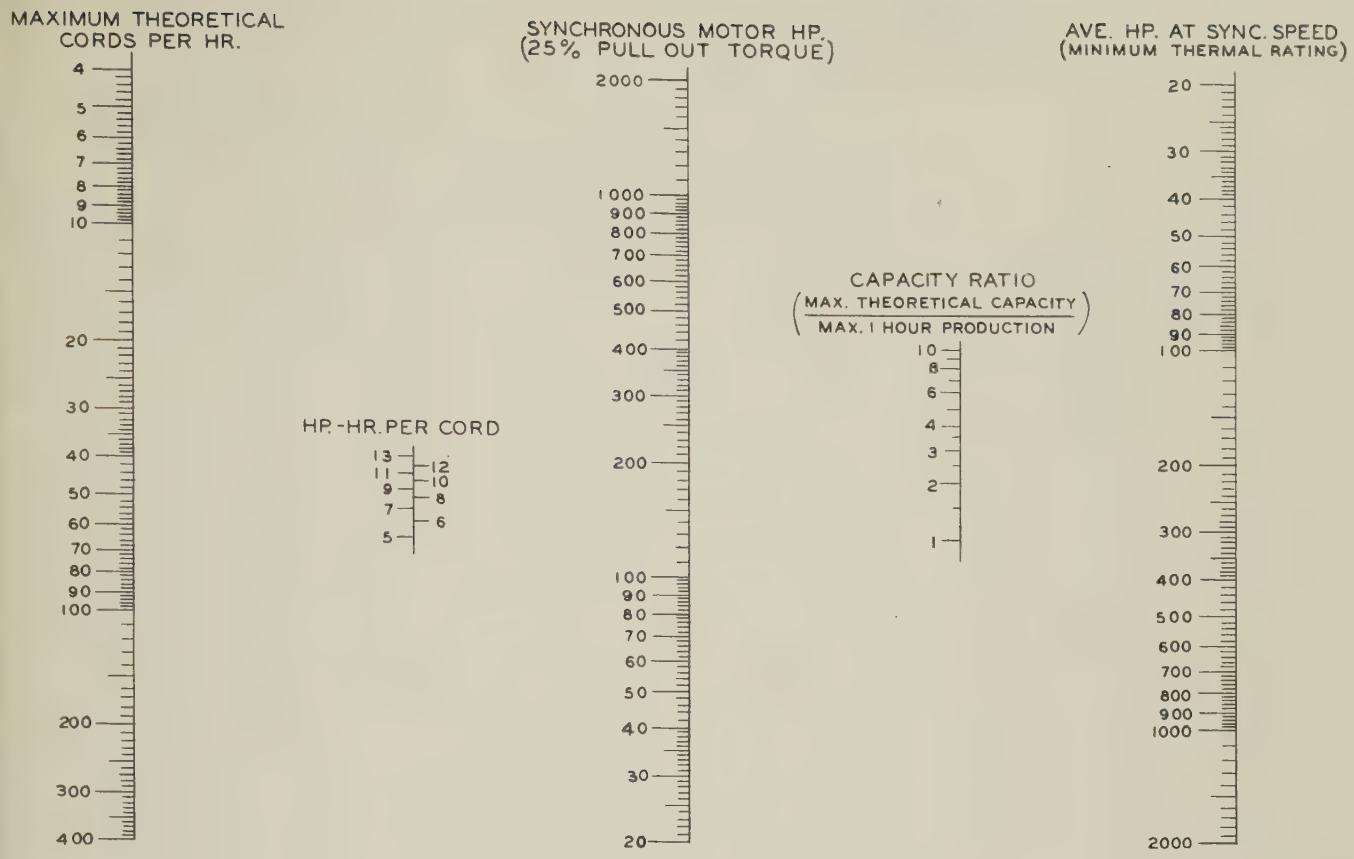



*Fig. 3*

4. Feed in feet per minute = r.p.m. × knives × chip length, in. × 12 = ____.
5. Chipper $WR^2$ ____.
6. Desired minimum chipper speed after chipping maximum diameter log:
   Normal slip squirrel cage motor 1–2% slip
   Wound rotor motor—no external resistance } 90% speed
   High slip squirrel cage motor 3–4% slip
   Wound rotor motor 2–3% external resistance } 85% speed
   Very high slip squirrel cage motor (5–8% slip)
   Wound rotor motor 4–6% external resistance } 70% speed
7. Chipper energy released in chipping maximum log (Fig. 4) = ____.
8. Maximum log diameter = ____.
9. Horsepower-hours per cord (selected in accordance with wood species) = ____.
10. Length of log = ____ ft.
11. Energy consumed in chipping maximum diameter log (Fig. 4) = ____.
12. Required energy from motor (line 11 minus line 7) = ____.
13. Required motor based on minimum chipper speed of ____ % (Fig. 5) = ____.
14. Maximum production rate (maximum rate for 1 hr.) = ____ cords per hr.
15. Required motor based on required maximum production rate (Fig. 5) = ____.
    Required motor size is the larger of the values obtained in line 13 or line 15 = ____.
16. Average log diameter required to meet maximum production rate based on logs being fed end on end (Fig. 6) = ____.

## SUMMARY

The most important single factor influencing chipper drive selection is the maximum production requirement. This production figure is for a 1-hr. period. In $^1/_2$ hr. full temperature rise of the motor can be obtained. With a service factor of 15%, extreme production requirements would probably carry past the service factor in 1 hr.

Mill management should determine maximum production requirements realistically. Many chippers are operated intermittently. Even when chippers run three shifts, the wood delivery is anything but a steady flow. For one reason or another, there is frequently a shortage of chips and wood is poured into chippers in an effort to get ahead of pulp production. The motor should be sized to take care of these production peaks and in keeping with predicted increased production.

Assume that a wound rotor induction motor has been selected. It meets the thermal requirements set by the maximum production and the slow-down as determined by the largest log, there is a final check that should always be made. The maximum end-on-end log diameter capable of being chipped should be calculated by formula or nomograph and this diameter compared to the average diameter of the mill logs. If this diameter is smaller than the mill average, then the motor rating should be increased by their ratios. Out of 18 cases checked by the committee, nine have drives that are too small to chip the wood with average diameters as reported. In fact, one mill is having to change the drive because of this factor.

There has been no consistent method of chipper drive selection used in the industry. In most cases chipper capacities are greatly in excess of the drive capabilities and the ratios of the two are not comparable. Possibly the reason for this condition is that the drives have not increased in the same proportions as the number of knives. Fortunately, few mills have had trouble with this condition and they may not until they try to utilize more of their chipper capacity.

Two salient wood characteristics affecting load are specie and wood diameter.

A chipper designed for chipping "soft" woods would

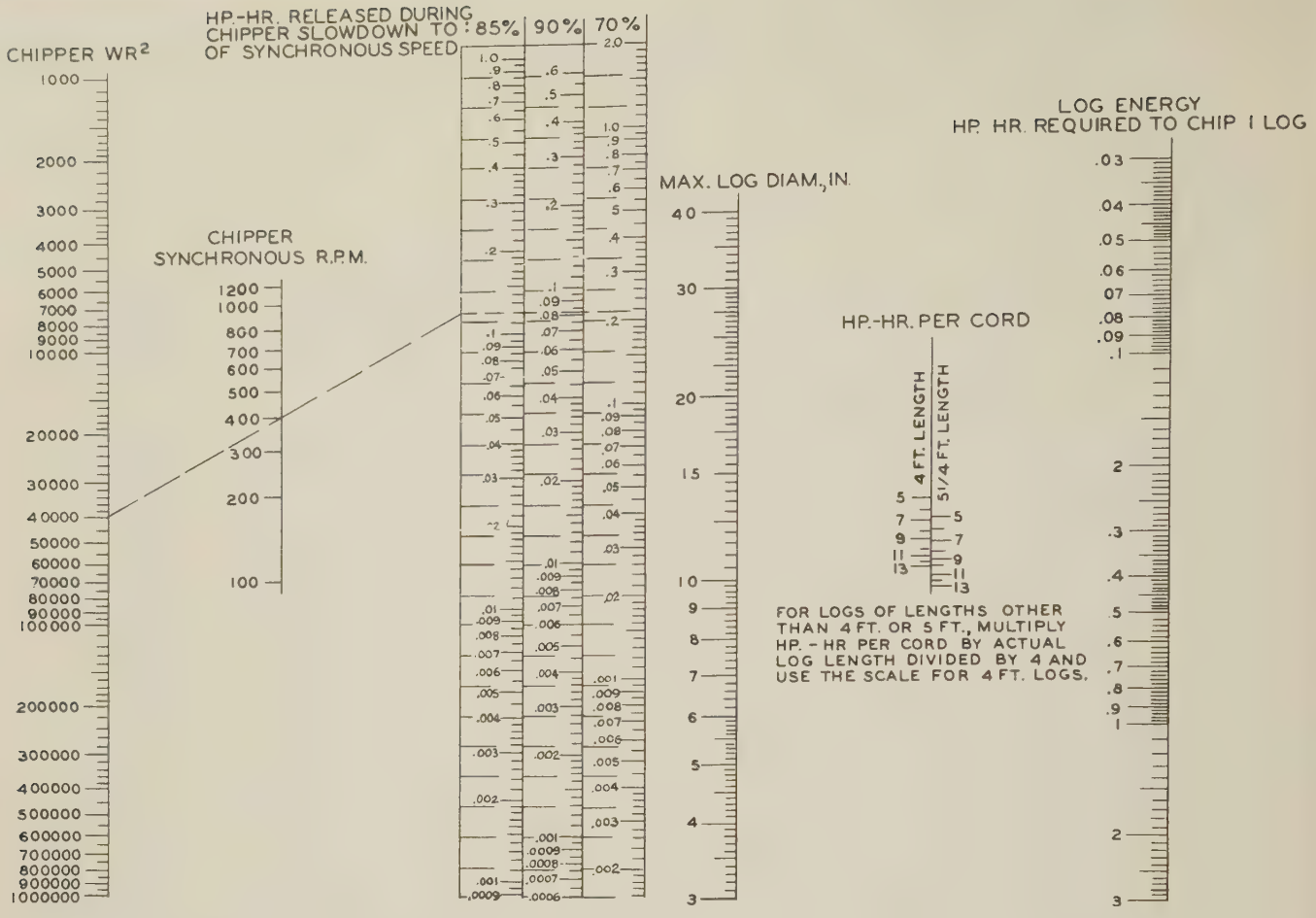

CHIPPER WR²
HP.-HR. RELEASED DURING CHIPPER SLOWDOWN TO : 85% 90% 70% OF SYNCHRONOUS SPEED
CHIPPER SYNCHRONOUS R.P.M.
MAX. LOG DIAM., IN.
HP.-HR. PER CORD
4 FT. LENGTH
5 1/4 FT. LENGTH
FOR LOGS OF LENGTHS OTHER THAN 4 FT. OR 5 FT., MULTIPLY HP.-HR PER CORD BY ACTUAL LOG LENGTH DIVIDED BY 4 AND USE THE SCALE FOR 4 FT. LOGS.
LOG ENERGY
HP. HR. REQUIRED TO CHIP 1 LOG

*Fig. 4*

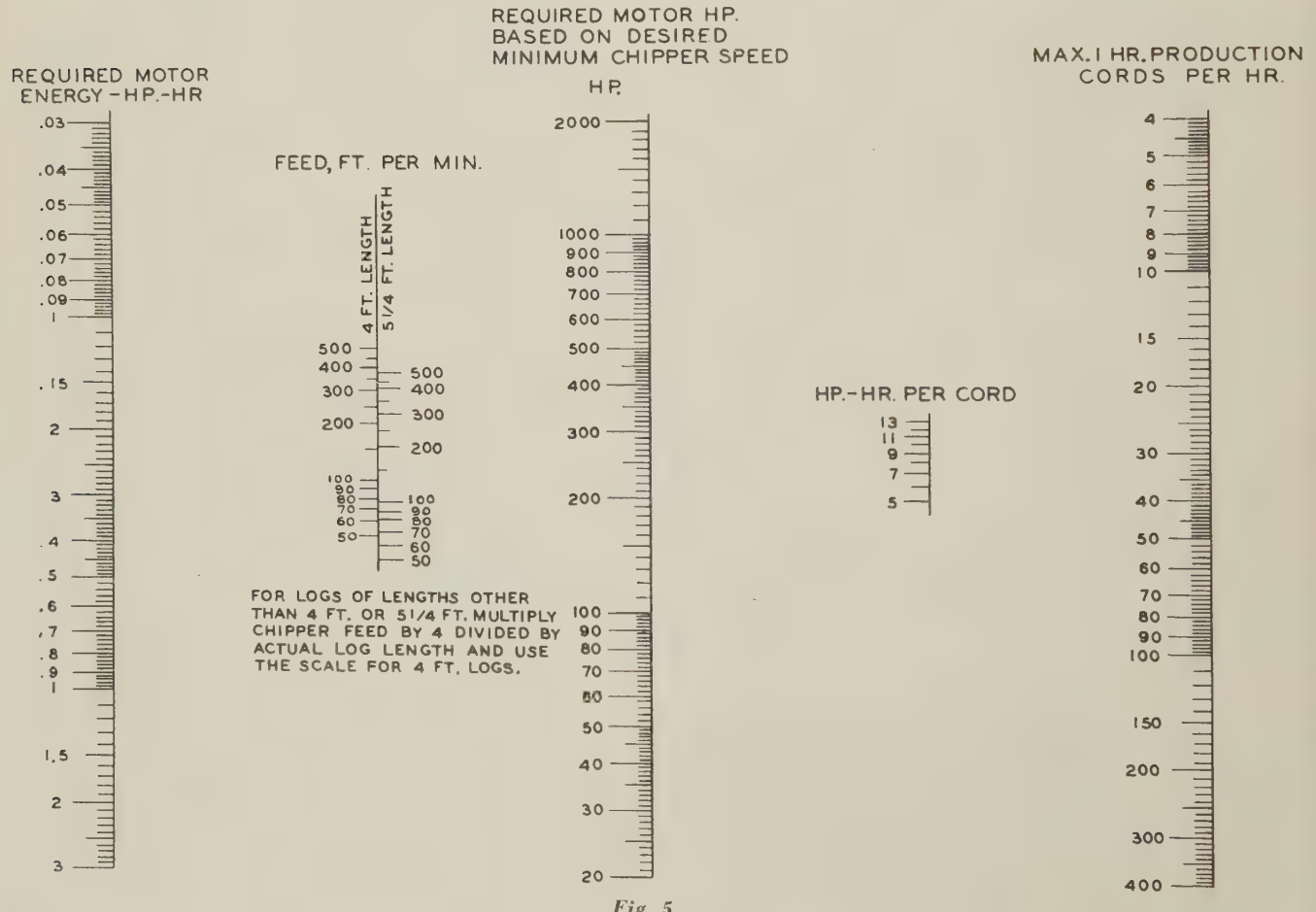

REQUIRED MOTOR ENERGY - HP.-HR
REQUIRED MOTOR HP. BASED ON DESIRED MINIMUM CHIPPER SPEED
HP.
FEED, FT. PER MIN.
4 FT. LENGTH
5 1/4 FT. LENGTH
FOR LOGS OF LENGTHS OTHER THAN 4 FT. OR 5 1/4 FT. MULTIPLY CHIPPER FEED BY 4 DIVIDED BY ACTUAL LOG LENGTH AND USE THE SCALE FOR 4 FT. LOGS.
HP.-HR. PER CORD
MAX. 1 HR. PRODUCTION CORDS PER HR.

*Fig. 5*

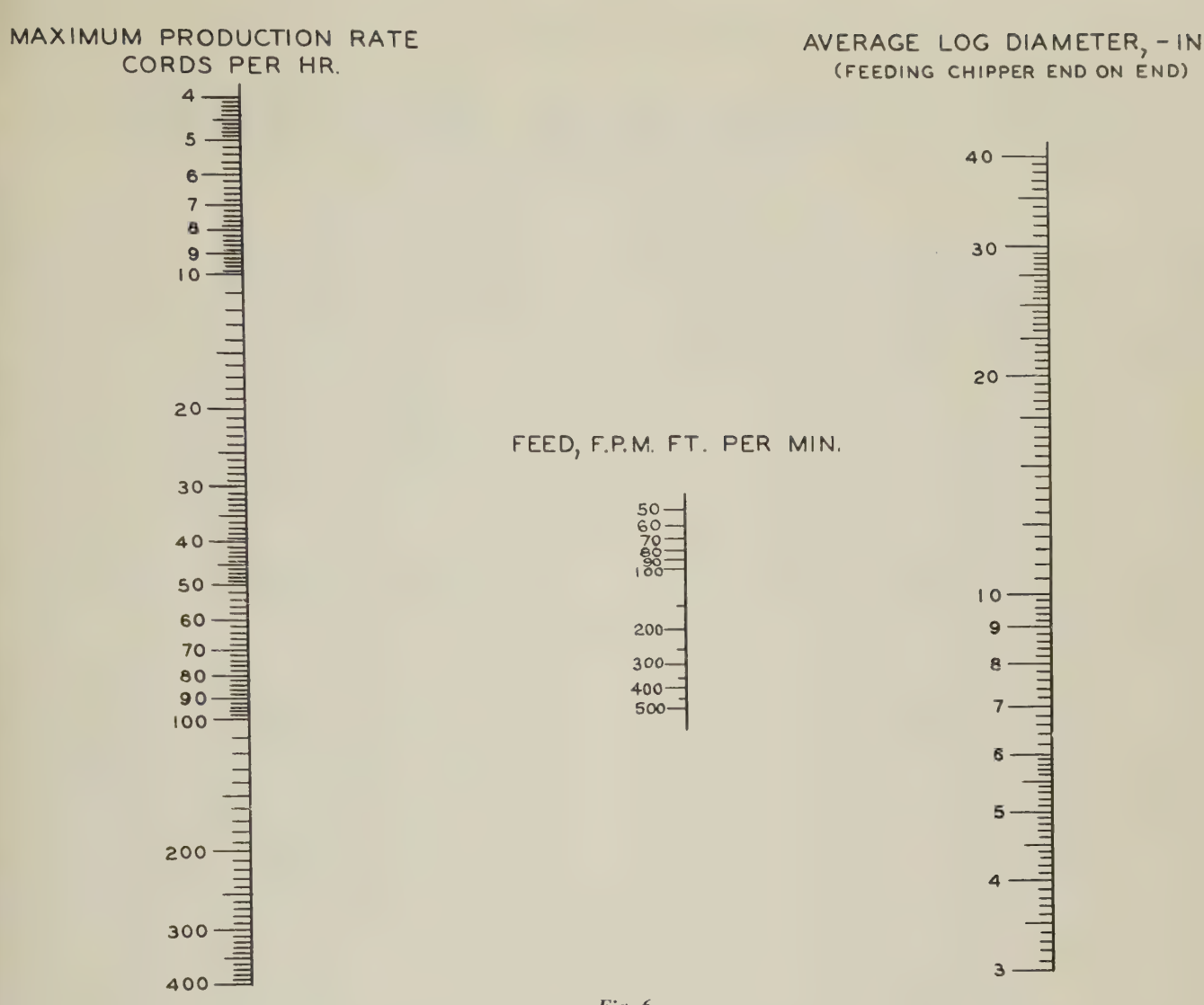



*Fig. 6*

not produce equal quantities of "hard" wood chips for the same energy consumption.

The most economical synchronous motor drive is 250% pull-out torque and 0.8 power factor. In general, wound rotor induction motors can be applied to chippers with smaller ratings than synchronous motors. The electrical system should be carefully studied if synchronous chipper motors are to be applied. The stored energy of the system should be great enough and the governing system quick enough to keep the rate of change of frequency at the buses less than about 0.6 cycles per sec.[2]. The maximum frequency deviation should be less than $\pm 1.0$ cycle per sec.

The cost of drive motors usually makes a belt drive more satisfactory than a direct drive.

If the chipper has a chip blower for conveying chips, this incremental power should be figured separately. If the chipper has a blower and a wound rotor motor drive, then care should be taken that the slow-down is not so great as to cause plugging of the ducts. Some designers feel that slow-down in these cases should not exceed 15 or 85% minimum speed. Many mills do not convey chips with a blower so the slow-down can be any value up to about 45% with resultant savings in motor size in most cases, providing chip quality does not suffer. It is not the aim of the committee to discuss constant speed chipping. The committee agreed on a slow-down of 25% as sound practice. This slow-down can be greater than 25% and still use both systems of motor selection.

The committee is making a recommendation to TAPPI for funds to further this study. Tests received so far indicate that laboratory work would be well in order to study the more important phases of this work. The experience of members of the committee indicates that knife angle, dryness of wood, type of grinding, and the log diameter were all contributing variables in the power requirements for chipping.

A list of factors as they affect power requirements has been prepared for a laboratory investigation: (1) Knife grind: (a) single bevel, (b) double bevel, (c) single bevel with back grind. (2) Spout angle. (3) Species of wood: (a) effect of diameter, (b) moisture content, (c) seasonal variation, (d) sectional variation. (4) Effect of chip length.

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This committee voices its appreciation to Westinghouse Electric Corp., General Electric Co., Electric Machinery Co., Carthage Machine Co., J. E. Sirrine Co., Brunswick Pulp & Paper Mills, Crossett Paper Mills, Gaylord Container Corp., Southland Paper Mills, and Bowaters Southern Paper Corp. for releasing the members of this committee who are in their employ to work on this project. It is particularly indebted to R. R. Baker, G. E. Shaad, and G. L. Oscarson for their work and to the 39 mills who contributed chipper data.

# A Study of Variation of Basis Weight and Caliper

MAYNARD S. RENNER

**The use of the "span" plan (a method of process capability analysis developed by Seder and Cowan), for study of a large amount of data from paper mill run sheets proved a workable method for obtaining a description of a paper mill process in terms of a simple set of numbers from which other and more detailed studies flowed naturally.**

DICTIONARIES define two kinds of statistics "plural" and "singular." Plural statistics are masses of data. Singular statistics is the body of organized methods for studying data, based primarily upon the mathematics of probability. The data contained in a group of paper mill run sheets are, in a sense, plural statistics and this paper is about a use of a method of singular statistics to study the plural statistics of one such group of paper mill run sheets.

The purpose behind this study was to develop a summary of the content of this group of run sheets in a way that would be simply and easily understood by operating and research men. First, data from a number of randomly selected runs were plotted in multi-vari chart form. This chart was interesting but its meaning seems to be vague and diffuse. Was there a better way of summarizing these data?

## THE SPAN PLAN

An Article, "The Span Plan—A New Method of Process Capability Analysis" by Leonard Seder and David Cowan in the 1953 Quality Control Conference Papers looked promising. This article describes a systematic approach to this general problem by developing a series of estimates of variability of a production process at successively finer stages or levels of the process. The procedure was developed from a method of analysis of variance based upon ranges discussed by David and Hartley and in other earlier articles published in *Biometrika*.

This procedure, Seder and Cowan say, has the values of (1) being based upon simple statistical methods, (2) giving tests of practical instead of statistical significance (in those cases where statistical significance might be small enough to have no practical significance) and (3) of yielding a graphic picture of the results of the analysis. The method is a sampling method meant to be used to study variation of individual pieces, but the authors point out "its principles are applicable to the continuous processes of the chemical, textile paper, and other industries." It was not hard to visualize the items of run sheet data as so many pieces of production from known times and places in a production process.

Use of the procedure "involves the assumption of normally distributed quality characteristics," but there is much evidence that this assumption, right or wrong, works in dealing with paper machine data. The method is a range method, but it is given as having practical value in situations very like this one. Also the data are cheap in the sense that they have already been gathered and, as Hartley points out, it is under these circumstances that range methods are particularly applicable.

The procedure was tried first on basis weight data (pounds per 500 sheets 24 × 36). First step was to separate among-run and within-run variation. The procedure, with tables of factors, was worked out for only definite combinations of numbers of lots sampled and number of samples within lots, to insure that "within a certain risk level," any effects found to be statistically significant would also be practically significant. Ten runs were selected, using a table of random numbers and then six basis weight values were selected from each run, also using a table of random numbers.

## CALCULATIONS AND RESULTS—BASIS WEIGHT

Calculations are simple and can be done with a slide rule and pencil. They are summarized for the among-run, within-run comparisons in Table I. To estimate within-run variation, the range within each column (run) is determined. These values are summed and divided by the appropriate factor, $C_{un}$ (from Seder and Cowan's tables) to give an estimate of three times the standard deviation or the expected plus or minus variation within runs.

To estimate variation among runs calls for just a little more work. The range of the column sums is divided by the appropriate factor, $C_{if}$ (from Seder and Cowan's tables) and squared. From this value is subtracted the square of the estimated within-run variation found previously. The difference is divided by the number of items in the columns. The square root of this value gives the estimated variation among runs in terms of three standard deviations.

The over-all plus or minus variation as 3 standard deviations is estimated by taking the square root of the sum of the squares of the previously estimated within-run and among-run variations. To get the grand average, each run column is summed, these subtotals are summed and divided by the total number of samples. The total process spread is then estimated by adding and subtracting these values to and from the grand average.

A simple test for widely different variations within runs (columns) is made by dividing the range of the column ranges by the value found for within-column variation and comparing the value obtained with a table of significant values for this ratio ($Q$) prepared by Seder and Cowan. Since the value found for this ratio (0.56) was less than the significant value for $Q$ of 1.27 it was concluded that there was no reason for believing the variations within runs to be different. The among-run variation was found to be less than 10% of the total variation and hence not significant, practically or statistically.

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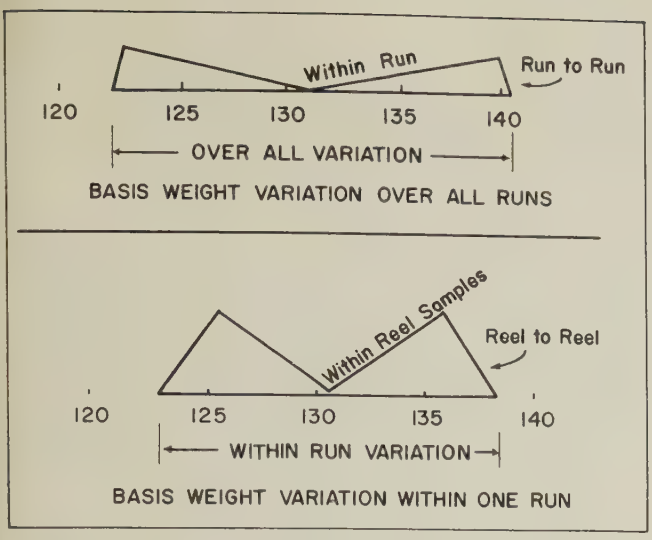


*Fig. 1. Pictograms for basis weight*

The next step was to examine basis weight variability within runs. One run was selected at random, but in a limited sense, the choice being restricted to those runs having a fairly large number of reels, and ten reels were then selected at random from this run. The run sheet data then provided a set of six systematically taken basis weight values for each reel. Estimates of total among-reel and within-reel sample variation were calculated. The total variation as 3 standard deviations was found to be ±7.87 lb. which agreed not too badly with the previously obtained estimate of 8.94 lb. Variation among reels was estimated (as 3 standard deviations) to be ±4.66 lb. and variation within reel samples was estimated to be 6.35 lb.

Note that this among-reel variation, so-called, contains all of the machine direction variation, including any within-reel variation that may be occurring. In other words, among-reel variation has been confounded with within-reel variation. From experience it seems reasonable to believe that a large part of this variation is true reel-to-reel variation caused by consistency and over-all time changes. However, no more information about this point could be obtained from the run sheets since they could not be subdivided further.

The results can now be shown graphically (Fig. 1). It is clear that most of the basis weight variation is occurring within runs, with somewhat more occurring within reel samples than is occurring among reels.

These charts, which Seder and Cowan call pictograms, are laid out with a compass and a ruler. They work because they take advantage of the similarity of the geometrical relationship that the square of the hypotenuse of a right triangle is equal to the sum of the squares of the other two sides to the statistical relationship that the square of the over-all variation from two (or more) sources is equal to the sum of the squares of the individual variations, when the individual variations are independent.

## STUDY OF CALIPER VARIATION

Caliper variation was studied next. The caliper data for the same samples used in the basis weight study were separated in the same way as for the basis weight study, into run-to-run and within-run variation and then between-reel and within-reel sample variation. The over-all variation as 3 standard deviations was estimated to be ±1.99 points or thousandths. The within-run variation was estimated to be ±1.92 thousandths so that again most of the variations were occurring within runs. The estimated over-all caliper variation for the same run (and same reels) studied for basis weight was found to be ±2.19 thousandths; for between-reel variation ±1.65 thousandths and within-reel-sample variation ±1.44 thousandths. These data were then ready to be summarized in a pictogram just as the basis weight data had been summarized (Fig. 2).

## VALUE OF STUDY

Now what had been accomplished? In a few hours' work, most of it spent in learning the procedure, for the actual calculations take only a few minutes, about

**Table I. Analysis of Basis Weight Over All Runs**

| *19920* | *19809* | *19530* | *19725* | *19110* | *19497* | *19496* | *19446* | *19805* | *19605* |
|---|---|---|---|---|---|---|---|---|---|
| 132 | 131 | 134 | 130 | 134 | 126 | 130 | 130 | 127 | 129 |
| 132 | 133 | 132 | 132 | 131 | 134 | 134 | 134 | 128 | 138 |
| 131 | 130 | 134 | 128 | 125 | 134 | 132 | 132 | 134 | 136 |
| 134 | 128 | 126 | 125 | 135 | 132 | 132 | 132 | 130 | 135 |
| 127 | 132 | 127 | 135 | 125 | 131 | 133 | 133 | 127 | 130 |
| 133 | 133 | 134 | 125 | 130 | 127 | 136 | 136 | 130 | 133 |
| 789 | 787 | 787 | 775 | 780 | 784 | 797 | 797 | 776 | 801 |
| 7 | 5 | 8 | 10 | 10 | 8 | 6 | 6 | 7 | 9 |

1. Unresolved factor (within runs):
   $\Sigma Run = 76$; $C_{un}{}^{a} = 8.50$; $3\sigma_{un} = 76/8.50 = 8.94$
2. Isolated factor (among runs):
   Range of totals ($R_{if}$) $= 801 - 775 = 26$; $C_{if}{}^{a} = 2.6$; $26/2.6 = 10$; $3\sigma_{if} = \sqrt{\frac{10^2 - 8.94^2}{6}} = 1.99$
3. Total:
   $3\sigma_{sp} = \sqrt{1.99^2 + 8.94^2} = 9.10$; $\bar{x} = 7866/60 = 131.2$
   Upper process limit $= 131.2 + 9.1 = 140.3$
   Lower process limit $= 131.2 - 9.1 = 122.1$
4. Does isolated factor contribute 10% or more to total?
   $\frac{9.10 - 8.94}{9.10} = 1.75\%$
5. Are within-column variations alike?
   $5/8.94 = 0.56$; therefore alike ($Q = 1.27$)

[a] Corrective factors.

6000 items of data had been summarized into four charts. It was now possible to sit down with people and by means of these charts tell them, understandably and reasonably authoritatively what the pattern of variation on this machine was like. This mass of data also had been summarized into a few simple numbers which could serve as benchmarks or a framework of reference for future study—as a means of coming to grips with the problem.

These numbers, it is true, needed to be used carefully. They were approximate estimates rather than statistics in the narrow sense to which quantitative confidence limits could be attached—not enough was known about the nature of the data from which they were obtained. Furthermore, as might be expected, the process was not stable so that although repeated analysis of the same run gave consistent results, analysis of different runs gave different results. However, the meaning of the results was not changed, in each case the greater portion of the variability was attributable to within-reel samples but the proportion varied widely, from 68.0 to 94.4% and the total variability ranged from the 7.87 lb. reported above to 10.92 lb.

The important point was that this analysis gave a method of coming to grips with the problem. It yielded numbers by which the entire process could be described, approximately but also simply and understandably. From this beginning, other simple studies flowed naturally. The variability in cutting and weighing samples was estimated and found to be susceptible to, and in need of, reduction. Some basic data regarding the inherent small piece weight and caliper variations, both of which were found to be of considerable size, were obtained and further important information about the nature of the process was developed.

## APPENDIX: THE NATURE OF THE LONG TERM BASIS WEIGHT AND CALIPER VARIATION ON THIS MACHINE

Reel-to-teel basis weight variation may be considered to be the sum of variations in machine speed, consistency, and rate of flow of furnish from the headbox. For this particular beater-batch size, stock chest size, and sampling schedule, the consistency of furnish at each sampling time is practically independent of the consistency at any other sampling time. It seems reasonable to look upon consistency, machine speed, and rate of flow of furnish as random variables about those values that come closest to giving the desired mean basis weight. Thus, the reel-to-reel basis weight variation should be random. Any short time cycling which may be occurring, even if systematic, will nevertheless appear in the reel-to-reel variation as a random effect, since these samples were taken without regard for (or, in fact, knowledge of) the occurrence, if any, of such short term effects.

Cross machine sampling is done at six positions across machine. Are these samples taken from a population of six, and only six, cross machine positions or do they come from an infinite population of cross machine values? If the random distribution of cross machine basis weight specified by Warren Purcell for ideal operation of a paper machine existed on this machine, each sample taken would represent all possible samples. If the cross machine positions always maintained a constant relationship to one another, one always high, one always low, etc., by consistent amounts, then each sample would represent only its position and the six samples would be from a total population of six positions.

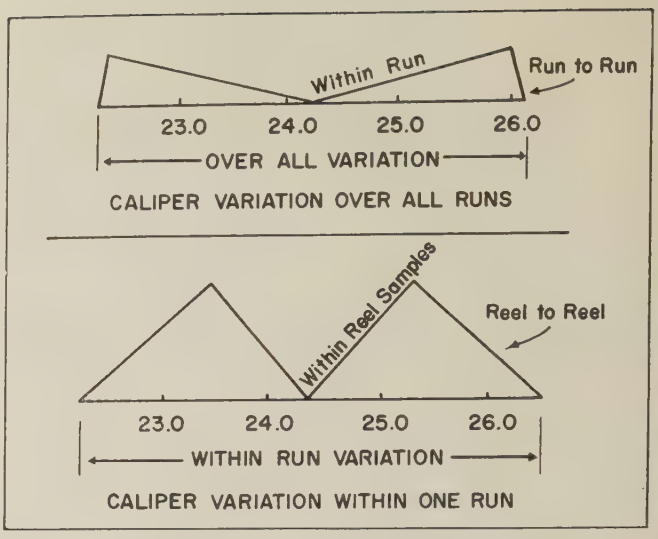


*Fig. 2. Pictograms for caliper*

Actually, experience shows that on this machine there is usually a high and low position within a run, but these positions shift from run to run (sometimes within a run). Thus, on this machine it would seem reasonable to look upon these six positions as six production machines limited to six at any given time, but nevertheless representative of a wide variety of such machines.

Caliper is influenced by all the factors that influence basis weight and, in addition, by variation in the preparation of the furnish which produces density variations and, on this machine, possible variations in the pressure of the couch roll. Although the relationship of density to caliper is inverse (density = basis weight/caliper), basis weight and caliper are the primary controls on the machine. So it seems not unreasonable to consider caliper variation due to variations in preparation of furnish to be random about the desired mean caliper value.

Consistent cross machine unevenness in the setting of the couch roll would, of course, produce systematic cross machine caliper effects, however, examination of the run data failed to show that any one position was consistently high or low throughout all runs, although there were frequently consistently high and low cross machine positions within a single run. Therefore, it seemed reasonable to consider caliper cross machine positions, like basis weight cross machine positions, to be samples from a large population of possible cross machine positional effects.

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# Calender Cooling on the Modern Paper Machine

L. G. JANETT

**Air systems for modern machine calenders require greater heating removing capacity, more flexible operational features, and attention given to economy of operation. This requires additional equipment and means of subcooling of the air year around. The results of improvements in equipment are reflected in higher quality and uniformity of finish in the paper produced and in lightening the work load of a backtender to achieve this higher quality.**

A RELATIVELY lightweight sheet that has low and high spots can be partially corrected by the calendering operation. The mechanism of the problem can be described as follows:

First assume, only for explanation, that the crown of the rolls is such that a true straight line contact between the rolls exists and also that all roll surface area is at the same temperature. Now assume that a narrow strip portion of the sheet entering the calender is of thicker caliper and greater basis weight than adjacent strips. Over the narrow machine-direction strip area there will then be a higher nip pressure than in adjacent areas. More work of calendering will then be done on this strip and accordingly more heat of friction will result, and the roll will be heated to a relatively higher temperature in this area, causing it to expand somewhat more at this point than in the areas adjacent to it. Now that the roll diameter over the narrow strip is slightly increased the unit pressure increases further resulting in further unbalancing the nip pressures in adjacent areas along the nips. This cumulative effect accentuates the unbalanced pressure across the calender and brings into focus the need for calender cooling.

## THE GENERAL PROBLEM

To be more realistic the problem should be called more basically calender roll diameter control rather than calender "cooling." In order to control diameter, heating is probably just as important and possible as cooling. This is evidenced by a newsprint backtender's manipulation of friction pads under calender roll doctors to get proper heating effect.

It is logical that the unbalance of nip pressure is somewhat proportional to machine speed so that the problems on a newsprint machine largely apply on any high-speed paper machine.

The backtender may not realize it but he is dealing in minuscule dimensional roll diameter changes in fractions of thousandths of an inch. For example (and this is a rational approach, not strictly rigorous) let us examine a typical wide machine calender roll having a nominal diameter of 16 in. The linear coefficient of expansion of cast iron is 0.00000556 in. per in. per °F. change in temperature. Accordingly, the diameter of a roll exactly 16 in. in diameter at 70°F. mean temperature will be approximately as follows at various other roll temperatures:

| *Mean temperature, °F.* | *Actual diameter, in.* |
|---|---|
| 70 | 16.0000 |
| 100 | 16.0027 |
| 130 | 16.0053 |
| 160 | 16.0080 |
| 190 | 16.0107 |

Mean temperature in the above table represents the average temperature of a circular segment of roll taken at right angles to the long axis having a thickless $\Delta t$. It is evident that the temperature at the roll surface can be relatively high whereas the temperature near the center may be relatively low. In fact the internal roll temperatures may well be essentially uniform across the entire width of the roll with very considerable temperature variations along the longitudinal surface.

To illustrate the importance of small roll diameter changes, if there is a temperature difference of 10°F. between two contact points, say 1 in. apart along a nip, the resulting clearance between the rolls at the lower temperature point would be approximately 0.0006 in. Usually properly crowned rolls of uniform temperature along their axes are light-tight when in contact. When the rolls are running with a paper sheet through them, however, and high and low spots occur there is no doubt the existence of a "wavy" contact line.

Consider a newsprint sheet having a finished caliper of approximately 0.003 in. A roll diameter increase of 0.0006 in. at a point, or a 0.0003-in. increase in radius of each of two rolls in contact, would result in an increase in the gap opening adjacent to the hotter point of 20% of the sheet thickness.

It then follows that the actual average mean difference in roll temperatures in adjacent high and low points along a nip is in the nature of possibly a fraction of a degree up to a high of a few degrees at most. This is logical due to the high coefficient of heat transfer of the cast iron roll and the tendency for its heat content to equalize at all times.

It follows then that the higher the sheet caliper the less the importance of variation in gap opening. Whereas the difference in gap opening of 0.0001 in. represents 3.3% of the thickness of a newsprint sheet this same difference in gap opening would represent only about 1.1% of the thickness of 9-pt. corrugating media for example. There is no question, therefore, that from a rational approach the calendering cooling problem is greatest on light weight papers in general.

In reviewing the general evolution of calender cooling, it should be pointed out that over a long period of years the matter of putting air onto the calender rolls has been very largely an empirical application of air largely influenced by the general ideas of practical

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papermakers. There are a good many older machines that are equipped with a simple cross-header and anywhere from two to six blows directing the air onto the calender rolls near the king roll on the paper machine side of the stack with all or most of the outlets wide open directing the air on to the rolls without much attempt being made to cool certain spots. This is particularly true of machines making medium and heavy weight papers and boards at relatively slow speeds. In most of these systems, the distribution nozzles have been designed for the most part by the papermakers who have definite ideas on how the air should be directed and to which nips. These older systems have functioned satisfactorily partly because the machine speeds are low with resultant lower heat losses due to friction and power involved. Also, the standards of finish have not been as rigorous as they are today. By and large, the improvements in basis weight uniformity due to better wet and equipment on the machine have resulted in a somewhat more uniform caliper sheet entering the calenders and very possibly the high and low spots in the sheet today are considerably narrower than they used to be years ago. Accordingly, the need today is for diameter control of rolls over considerably narrower sections along the nip.

For the modern machine it now becomes necessary to increase the cooling effect on rolls and over narrower sections. It also has become evident that whereas papermakers in the past felt that the air could best be supplied lower in the stack in nips fairly close to the king roll, the papermaker of today is confident that air supplied to higher nips in the stack can achieve equal or better results in general.

With regard to the location of air distribution nozzles on a stack in older practice, air was only directed to the exposed steel roll surfaces on the paper machine's entering side of the stack. It now becomes apparent that air should be supplied to the first roll above the queen roll on the entering side of the stack, and on the second roll above the queen roll on the leaving side of the stack, with the necessary headers on both sides. In addition, a considerable number of papermakers feel it desirable to supply air to the queen roll on the leaving side of the stack. It is more effective to play the air on the steel surfaces of the rolls than on to the surfaces over which paper is passing because of the insulating effect of the paper sheet and its lower heat capacity. However, such additional cooling of the sheet effected by the air passing over it is desirable to hold paper moisture up and sheet temperature down.

## GENERAL DESIGN

With respect to the design of calender cooling equipment, there are two variables that can be controlled which affect the B.t.u. transfer of heat from the roll to the air cooling medium. First of all, the coefficient of transfer through the air film on the roll surface is increased with corresponding increase in air velocity past a given surface area. Secondly, the total heat transfer from the roll is proportional to the difference in temperature between the roll and the cooling air. It is then obvious that by increasing air velocity over the roll surface and by reducing the air temperature supplied, a greater rate of heat removal from the roll will result.

Increasing the velocity of the air over the local roll area is simply a matter of increasing the system pressures and represents a fairly simple solution of increasing the coefficient of transfer through the air film. Decreasing the air temperature supplied is also entirely possible by several methods of artificially cooling the air supplied to the stack. There is merit in trying to lower the temperature of the rolls in as narrow and local an area as possible because usually the hot spots do not cover a very wide section across the calender roll face.

To this end it then becomes desirable to use a lesser total quantity of air at considerably higher velocity to get the cooling effect at as high a rate as possible and in as restricted an area as possible. It is with this objective in mind that the modern high pressure calender cooling system is designed.

The requirement for higher velocity air supply has been proven by the fact that when a system provides inadequate cooling the addition of a compressed air hose supply of air provides the backtender with the necessary additional cooling to get the finishing results he needs. Needless to say, the cost of compressed air at from 90 to 100 p.s.i. is certainly excessively high for use on a machine calender because the velocities from a compressed air jet are actually higher than are necessary to get the maximum cooling effect of the air supplied.

## GENERAL EQUIPMENT SELECTION

Most of the older existing systems employ the use of the standard industrial steel-plate, paddle wheel type of fan which has the advantage of low maintenance and reliability of operation. This type of fan is suited for this purpose because as the various blows on a calender cooling system are shut off, the system pressure will rise and at the same time the volume transmitted to the remaining open blows increases slightly with resultant overall reduction of the brake horsepower required by the fan, so that the fewer blows that are open, the lower the power consumption. It is then logical to use the centrifugal compressor type of fan for the newer high pressure system which has essentially the same fan characteristics as the steel-plate, paddle wheel fan with probably a somewhat better characteristic in that its discharge pressure remains substantially constant regardless of the dampering or closing off of various blows. Whereas the older systems in use today have system air pressures of from a few inches of water up to 8 or 10 in. of water, modern systems will employ pressures of from $^3/_4$ to 2 p.s.i. depending on several variables and conditions of operation. In a modern system, the necessity for well-designed distribution nozzles is imperative and it is desirable to use positive manually operated butterfly valves of a rigid type instead of the makeshift leaking slides and other types of volume controls not the least used of which is the reliable rag stuffed into a blow by the backtender. Butterfly valves have visible position indexes on them and add another tool for flexible but positive operation for the papermaker.

With respect to the temperature of the air supplied, there is no question but what the temperature of this air is quite critical insofar as the results obtained on the calender are concerned. In some Canadian newsprint mills where very low outdoor temperatures of 0°F. and

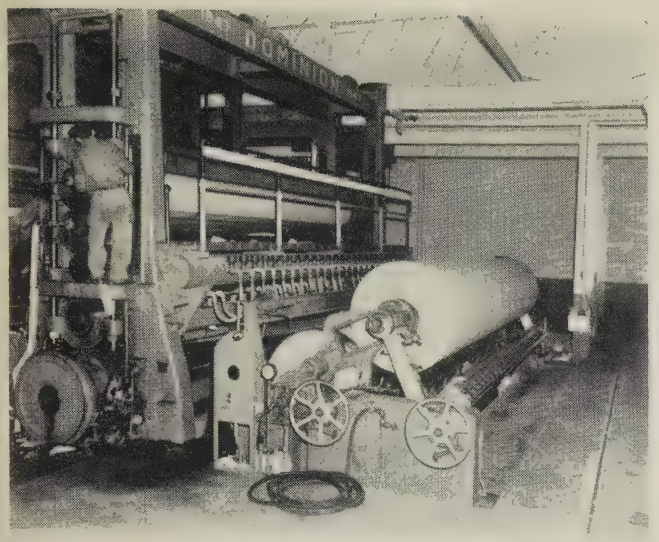

*Fig. 1. A high pressure calender air system showing air supply to the leaving side of the stack with remote manual controls for blows located just under reel bundle*

below are quite common, there have been cases where the air supplied to the calenders was taken directly from the outside during the winter as well as during the summer. It was found that extremely low air temperatures were somewhat objectionable probably because excessive cooling resulted and it was too difficult to control the calender roll diameter, and secondly, the use of the same volume of air summer and winter resulted in very wide fluctuations in results on the calender. Accordingly, some of these mills provide a mixture of outdoor and indoor air in the wintertime to arrive at a relatively uniform temperature the year around by further using artificial cooling of the air in the summertime. Ideally, it would be desirable to supply a uniform temperature of air to the calender the year around at the same level, substantially below normal room temperature.

## COOLING MEANS

There are approximately five methods of supplying subcooled air to a calender, the choice of which to use resting with the geographical location of the mill and the availability of cold water supply.

In Canadian areas where even outdoor temperatures in summer are relatively low, it is possible to get a fair degree of cooling and control of the temperature of the air supply by mixing outside air with recirculated basement air controlling the fresh air and recirculation either by remote manual damper operation or by automatic temperature controlling means. During hottest weather in these areas it is probably not possible to get air supply temperatures much lower than approximately 60 to 70°.

A second more widely used method in the Canadian areas is to use cooling coils supplied with a cold water supply. If water is available from the surface sources or wells at from 40 to 55°F. adequate cooling can be provided with control of the temperature by means of automatic or remote manual control of the water flow through the cooling coils. This has proved successful in upwards of 20 modern installations in Canada where adequate cooling water is available.

A third method of subcooling the air is by means of humidifying type of multistage air washer on the inlet to the calender cooling fan. By recirculating all water in the washer by means of an external pump, it is possible to cool the air entering the washer to very close to the entering wet bulb temperature with the air leaving the washer substantially saturated at its leaving temperature. In areas where the average wet bulb temperatures range between 50 and 75°F. it can be seen that effective cooling can result, although there is naturally difficulty in controlling this leaving temperature from week to week or month to month. It nevertheless is advantageous if no cooling water is available and it is not desired to invest in mechanical refrigeration.

A fourth method of cooling is to use a direct refrigeration expansion coil on the inlet side of the calender cooling fan with refrigeration supplied by mechanical means. It is possible to effect uniform supply air temperatures by either remote manually or automatically controlling refrigerant back pressure to the refrigeration machine, and by incorporating automatic unloading equipment auxiliaries. Because it is not feasible to recirculate the cooled air for the stack back to the apparatus, the refrigeration load is appreciable. A modern high pressure air system on a single machine calender over 200 in. in width would require approximately 20 tons of refrigeration in order to reduce the air temperature supplied by approximately 40 to 45°.

A fifth method of cooling the air which has not yet been exploited, is the use of a water coil on the apparatus, supplied with chilled water from an absorption refrigeration apparatus now available. This system would have no mechanical moving parts for the refrigeration cycle other than an external water circulating pump and would be supplied with low pressure exhaust steam and the usual condenser cooling water at approximately 85°F. This system has the advantage of very low operating cost, maintenance cost and trouble-free operation, but is of higher first cost than the usual mechanical refrigeration equipment now in use. Also, this type of equipment is now only available in 10 and 25-ton sizes.

## AUXILIARY REFINEMENT

On any system, except possibly one employing an air washer for cooling, it is almost a necessity to incorporate air filters to insure a clean supply of air to the calenders with attendant reduction in collection of dirt inside the apparatus equipment. It is also imperative when it is necessary to eliminate blowing of insects and bugs on to the calender sheets. Since the volumes of air to be handled are small, usually a washable type of filter is satisfactory, although it is entirely possible to use the more expensive oil curtain types and electrostatic types if the situation warrants this added expenditure.

On wide, high-speed news and light weight paper machines the problem of reel control is much aggravated, and the high and low spots in the sheets will almost always be moved from point to point during operation. This places a great deal of extra work on the shoulders of the backtender and it is not uncommon to find him moving from stack to reel almost all of the time he is working. On the theory that by making his work easier, a conscientious backtender will build a better reel automatically, there has been designed a remote manual automatic control system for changing

the points of air application and the volume of air supplied at each nozzle from a console located adjacent to the winding reel. By incorporating an air-operated diaphragm valve on each outlet nozzle and by installing on the control console a gradual switch for each valve it is possible for the operator to adjust air supply across the entire face of the calender without leaving the area where he is inspecting the reel. Such a system is shown in Fig. 1.

There has been some reluctance to install cross-headers and nozzle equipment on the leaving side of a calender because of its possible interference with operations and maintenance of the doctors and rolls themselves. It is possible, however, to design the entire header and nozzle assembly such that by disconnecting of a flanged connection at the rear, it is possible to raise and remove the entire header and nozzle assembly by means of the main machine room crane at such times when doctors and calender rolls are to be removed for maintenance.

### SUMMARY AND CONCLUSIONS

In general, it can be said that improved calender roll diameter control can be achieved by increased system pressures and velocities from nozzles, together with artificial cooling of the supply air. This, of course, results in a somewhat more elaborate calender cooling apparatus, and whereas in the old systems the horsepower requirement for the supply system has varied from $7^1/_2$ to 25 hp. for various width machines, with the new type equipment the fan horsepower required is increased to a range of from 10 to 75 hp. depending on the type and width of machine and the number of calenders to be supplied on one machine. Mechanical refrigeration increases the power required for calender cooling by from 10 to 40 hp. as a nominal maximum based on present-day design.

It should be pointed out that calender cooling systems cannot be expected to be effective in adjustment of crown of calender rolls which is entirely a separate problem. The system is intended to provide such small adjustments in roll diameter as are required because of the smaller variations in the sheet coming off the paper machine driers.

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# Outdoor Power Plants as Applied to the Pulp and Paper Industry

J. R. CHAPMAN

**Outdoor power plants with varying degrees in building enclosure have been in use for many years. Savings in construction can be realized by reducing the extent of enclosed areas. Other factors, however, influence the total savings and often the disadvantages of outdoor operation offset the reduction in first cost. A comparison of the construction costs of recent power plants shows that the building enclosure account ranges from 2.08 to 8.15% of the total cost of the project, depending on the extent of the enclosure. A detailed cost analysis of three types of power plant building, as compared to a base outdoor design, shows that a full enclosure costs from $2.02 to $2.26 per kw. more than the base and a fully enclosed insulated design costs from $2.81 to $2.87 more than the base.**

The outdoor power plant, either for industry or utilities, has received much publicity and aroused a great deal of controversy both with regard to construction economy and operational facility. The oil industry originated the outdoor process plant and the utilities have adopted the idea in varying degrees. So-called outdoor power plants in which the use of enclosure has been minimized but not entirely eliminated are operating in all parts of the country. This type of plant design has not been as readily accepted by the manufacturing industries and this discussion will consider some of the advantages and disadvantages of the outdoor power plant to the pulp and paper industry.

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Why should power plants be enclosed? Is it merely a practice carried over from the days when generating equipment was in the development period and its reliability needed to be nurtured by every means available, or is protection of personnel and equipment essential to efficient and continuous operation? It is generally agreed that power plants are enclosed, first, for the protection and comfort of personnel, second, for protection of equipment, third, to facilitate maintenance, and fourth, to present a pleasing appearance and preserve the good will of neighbors. Included in the latter are plant extensions which carry on the same architectural appearance as existing structures. These four reasons should be examined under the cold light of impartiality and their importance be financially evaluated with respect to the type of operation and the over-all economics of the manufacturing plant. The correct answer will be found only when thorough engineering analysis has considered all factors and established the basic criteria against which first costs can be measured. Popular trends or personal opinion should play no part in the selection of the type or extent of building enclosure.

Essentially, different basic considerations govern selection of equipment and type of construction for utility and industrial power plants. A utility central station generates power as a primary product for sale as kilowatt-hours. A pulp or paper mill consumes kilowatt-hours as a raw material in the production of a commodity of specialized and varied type. Since the

utility must have adequate reserve capacity at all times to supply kilowatt-hours, consideration of type of construction would be somewhat different than for a plant for a pulp or paper mill having no such reserve. The production of paper requires substantial quantities of steam and power. Supply of these utilities must be coordinated with pulp or paper production requirements and such factors as availability and maintenance of power generating equipment must be regulated to suit production, as far as possible.

## BASIC TYPES OF ENCLOSURE

There are fundamentally three basic types of power station building. The first type is the so-called outdoor or minimum enclosure arrangement, the second is the semioutdoor type with only the principal heat generating equipment and its auxiliaries left uncovered, and the third is the fully enclosed plant.

Before considering illustrations of these three types, it is appropriate to look at an outdoor plant which is unique in that it is all outdoors. Figure 1 shows a boiler plant built for a refinery which is conspicuous by the absence of any kind of enclosure. As a rule this practice is not followed in most outdoor power plants which differ mainly in the extent and number of enclosed areas.

Figure 2 shows the Freeport, Tex., industrial-type power station of The Dow Chemical Co. which is comparable to a typical pulp and paper mill installation. This station was designed as an outdoor type but with provision for enclosing the turbine room at a later date if operating and maintenance difficulties made it desirable. This station supplies steam and power to manufacturing processes, and high availability is required.

Figure 3 shows the Etiwanda steam station of the Southern California Edison Co. in Southern California, which is a fine example of outdoor design in an ideal climate.

Figure 4 shows a semienclosed plant where some optional protection is provided by a roof over the boilers, although this is not always necessary. The Moss Landing steam plant of the Pacific Gas & Electric Co. in Monterey County, Calif., is a good example of exposed steam generating equipment with enclosed turbine room and auxiliary bay.

Figure 5 shows the semioutdoor extension recently

*Fig. 1. This outdoor plant is outdoors*

*Fig. 2. Power plant, Texas Div., the Dow Chemical Co., Freeport, Tex.*

completed for Columbia-Southern Chemical Corp. at Corpus Christi, Tex., which is also similar to a power plant in a pulp and paper mill, supplying extraction steam to process in the generation of power. In this case, the turbine room was enclosed to make maintenance work as nearly independent of high winds and heavy rains as possible. The boilers are semioutdoors to the rear of the turbine room.

The fully enclosed or conventional design has been most widely employed in the pulp and paper industry. A few illustrations are offered here.

Figure 6 shows the new station of the Great Northern Paper Co. at East Millinocket, Me. A complete insulated enclosure is employed for maximum protection in extreme hot and cold weather conditions.

Figure 7, the Hookers Point station of Tampa Electric Co., is a completely enclosed station in a warm climate, but where rains are frequent, heavy, and often accompanied by high velocity winds making any kind of maintenance and outdoor operation extremely difficult.

Figure 8, showing the West Springfield station of Western Massachusetts Electric Co., shows an example of the selection of an attractive brick superstructure at premium cost to conform to requirements of the area in which the plant is located.

There are many more variations in power station enclosures or lack of enclosures, and the illustrations reviewed are intended only to represent general types and not necessarily ideal designs. Where enclosures are used of either low or premium cost construction the building architecture should be kept functional. Proper arrangements of building lines and masses can result in a pleasing appearance without increasing the cost.

## RELATION OF ENCLOSURE COST TO PROJECT COST

The main purpose of part or total omission of the building enclosure is to reduce costs. A proper perspective should be maintained as to the comparative value of the building enclosure in relation to the total installed cost of the power station. To illustrate the relationship between the costs of the various parts of a station, costs of three typical power stations, recently completed, were segregated and the results illustrated by circular graphs. Figure 9 shows three graphs. The first is for a minimum enclosure design in a warm climate. The second is for a low cost total enclosure in a moderate climate. The building consists of uninsulated corrugated asbestos with concrete slab roof. The third graph is for a premium cost masonry enclosure in a cold climate. This power station is located in the suburbs of a large city and public relations dictated the best type of red brick construction.

These graphs are not designed to show the dollar cost of building construction but are only to illustrate the relation of the building enclosure to the total cost of the

*Fig. 3. Etiwanda steam station, Southern California Edison Co.*

station. Engineering, construction supervision, taxes, insurance and other charges are distributed over the various sections. Variations in the cost of electrical work are not significant as no attempt was made to keep the scope of the switchyards the same for the three plants. There would, however, be some increase in electrical work for outdoor installations due to the increased motor and control costs. The amount of such increases should not be surmised from these graphs.

It is natural that the ventilation part of building service requirements should decrease with any reduction in the extent of the enclosure and station lighting would be expected to decrease in the same manner due to the more efficient use of floodlighting. The variation in cost of enclosure from 2 to 8% shows the structural saving of a minimum enclosure over fully enclosed masonry construction. This spread can be substantially reduced by using low cost building materials which will afford complete protection with but a slight sacrifice in appearance.

The minimum enclosure design covers an extension to an existing station of one 30,000-kw. unit and a 335,000-lb. per hr. boiler. The turbine and turbine control board are enclosed in a sheet metal walk-in enclosure having a removable roof for access to the turbine during repairs or dismantling. The main generator with its exciter and pilot exciter all have weatherproof casings and are completely outdoors. The boiler and its auxiliaries are uncovered except for an enclosed firing aisle which also encloses the boiler control board. Partial enclosures below the operating floor level house additional controls and critical auxiliary equipment. Although this design has been used to illustrate the cost distribution for a minimum enclosure, it is admitted that further reductions in the scope of the enclosed areas and the omission of "dog houses" can effect further economy in construction, although it is possible that such further savings may be offset by increased costs in equipment to obtain the same over-all immunity to the weather.

The low cost total enclosure design covers an extension to an existing station. The structure consists of steel framing, reinforced concrete floors, grating platforms and walkways, precast concrete roof, and corrugated asbestos siding. Interior partitions are of concrete block or brick. The complete enclosure allows minimum cost mechanical and electrical equipment and isolates operation and maintenance entirely from weather conditions.

The premium cost design covers an extension to an existing station of one 40,000-kw. unit and a 400,000-lb. per hr. boiler. The building frame is of structural steel with permanent exterior walls of brick and steel sash. The boiler room roof is flat reinforced concrete and the turbine room roof is of precast concrete tile.

### SPECIAL EQUIPMENT REQUIREMENTS

It must not be overlooked that in reducing or eliminating the building enclosure all cost adjustments do not result in credits. Locating critical mechanical and electrical equipment out-of-doors invites problems of operation and maintenance. Some equipment is readily adaptable to outdoor operation while others require special treatment.

The boiler which is normally in a casing needs relatively little more for adequate weatherproofing, particularly if a double casing is used. Although plastic casings have been used for outdoor boilers, the steel casing is preferred with a minimum of slip joints. It is customary to pitch the casing on top of the boiler to preclude water pockets. Where freezing temperatures are experienced the ends of the main steam drum may be enclosed or gage glass and drain lines electric heater traced. All soot blower lines should also be heater traced and soot blower retracting devices hooded.

Turbines located outdoors are provided with a specially designed waterproof shell. All bolted joints are gasketed and special precautions taken to seal-weld all joints which do not have to be broken. Some parts of a standard turbine must be protected from the weather such as the valve gear on top of the steam chest. Sometimes a walk-in enclosure is used covering the head end and sometimes the entire turbine. Operators having experience with full enclosures tend to agree that their benefits are not worth their cost and the problems of maintaining adequate ventilation within the enclosure. The trend is toward the use of waterproofed lagging without partial or total enclosures. Openings around the foundation must be sealed to prevent water from entering the space under the machine. The special lagging includes means for ventilating the various compartments, control valves, and bearings. The turning gear has its own enclosure and ventilation system.

The generator is completely exposed to the weather above the floor line except for enclosed ends and side lagging. Hydrogen-cooled units require special ventilation of the lagging to prevent the accumulation of hydrogen gas due to leaks in the system. The exciter and collector end of the generator are enclosed by removable covers or, alternatively, by an external walk-in type housing. Provisions should be made for supplying heat to the generator gas coolers during shutdown in cold weather. All oil, water, or hydrogen piping to or

*Fig. 4. Boilers for units nos. 4 and 5, Moss Landing steam plant Pacific Gas and Electric Co.*

from the generator that is not contained within protected spaces must be suitably protected from the weather. Thermal insulation of the generator may be required for certain climates.

The electrical work in outdoor plants requires special features. All control equipment must be weatherproofed, which in the low voltage class about doubles the cost. The cost increase for weatherproofing in high voltage controls is less, averaging around 10 to 15%. Motors of about 200 hp. and up are available in so-called weather-protected type. This class costs less than totally enclosed, but is available only in the larger sizes. Smaller motors should be totally enclosed. Weatherproofed motors cost more than splashproof, but eliminate the need for metal duct extensions to air intakes and discharges to prevent water being drawn into the motors during severe rainstorms. It is good practice to provide motors with internal heaters where this is possible.

Little extra needs to be done to fit the mechanical auxiliaries for outdoor use. Where piping and equipment need insulation, an extra layer of waterproofing material will suffice. Compressed air lines should be pitched and drained, and traced with electrically heated cable. In very cold climates, steam tracer lines are a constant source of trouble. Soil heating cable with thermostatic controls is more effective and its reliability is well worth its extra cost. It is advisable to use chemical driers in all control air lines to keep moisture to a minimum.

If the outdoor station is near residential areas, special attention should be given the noise level of auxiliaries. The use of silencers on boiler blow-off tanks and safety valve lines is effective in reducing noise. Fan design and duct work arrangement should be examined, as this is frequently a source of disturbance.

## STRUCTURAL MODIFICATIONS

In an enclosed plant the operating floor usually consists of a reinforced concrete slab with some type of surface finish. Where such a floor is out of doors and subject to extreme and sudden changes in weather conditions and it is necessary to protect either mechanical or electrical equipment below from water leakage,

*Fig. 5. Corpus Christi power plant, Columbia-Southern Chemical Corp.*

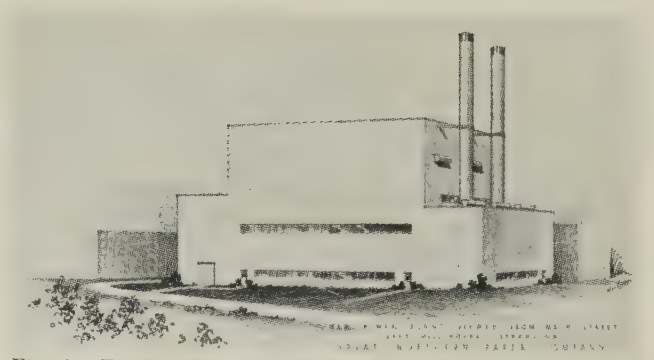

*Fig. 6. East Millinocket extension, Great Northern Paper Co.*

special precautions should be taken. This can be accomplished by installing a waterproof membrane over the base slab with a reinforced concrete wearing surface above properly jointed to minimize temperature cracks and with the joints adequately sealed.

When complete weather protection of equipment below is not required, a concrete slab with usual types of surface finish may suffice. Such a floor should have adequate temperature reinforcement and if supported on steel framing, the top flanges of beams should be adequately protected against moisture seepage and corrosion.

## VENTILATION

The need for ventilation is minimized by fully outdoor design. In such plants, forced ventilation is confined to control rooms, offices, and sections under the turbine housing critical equipment. Control rooms are generally air conditioned for best results. In semi-enclosed stations, the boilers and auxiliaries, including fans, duct work and precipitators, would be uncovered with firing aisle, auxiliary bay and turbine room enclosed. Since the major section of the heat producing equipment is outside, ventilation requirements are substantially decreased. Provision should be made, however, to furnish air to the boiler firing aisle and points in the operating area where personnel are stationed.

A totally enclosed plant, although requiring the most ventilation, actually offers opportunities for providing good ventilation throughout with little or no operating cost. It is sometimes possible to combine plant ventilation with boiler air requirements to the advantage of both, as was recently done in the power plant for a pulp and paper mill. Figure 10 is a ventilation diagram of the station which is of open design with no complete physical separation between the different areas. Platforms and walkways are of grating, allowing minimum interference with air flow. The forced draft fans, located at ground level, have their inlets arranged so suction can be taken from inside the building at the upper level or out of doors, or a combination of both. During the summer season the fans draw their full capacity from inside the station. Continuous roof ventilators mounted above the boilers exhaust the balance necessary to maintain comfortable temperatures in the building. The fuel oil room and the water treating building are provided with propeller-type exhaust fans.

Adequate ventilation can be provided at relatively low cost, particularly in a new plant where the arrangement can be laid out to facilitate air movement and

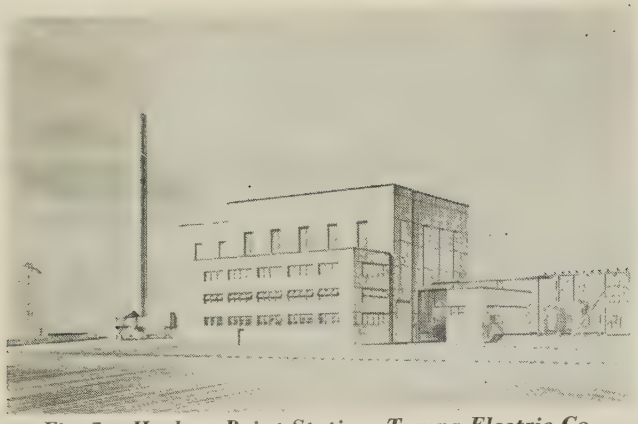

*Fig. 7. Hookers Point Station, Tampa Electric Co.*

eliminate pocketed areas. An item usually included in the building service account is an auxiliary boiler for providing heating steam in cold climates when the main boilers are down. It is also useful in making the initial charge of condensate and in maintaining an adequate supply during the critical start-up period. Although used primarily for building heating in cold weather, this auxiliary boiler cannot always be omitted by the elimination of the building enclosure.

### PSYCHOLOGICAL FACTOR

There is an interesting psychological factor in outdoor plant operation. In a hot climate it is difficult to maintain uniform ventilation in a power station building and hot spots, even though few and small in area, lead to operator dissatisfaction, while the same operators will work out in the open in direct sunlight with less complaint. The same situation has been reported in colder climates and stems from the prevalent impression that man-made conditons should be perfect, whereas nature is given a wide latitude of performance and variations in either direction from the mean are expected.

### MAINTENANCE

The problem of maintenance of equipment has long troubled plant operators responsible for scheduled production of steam and electric power. A public utility, manufacturing kilowatt-hours for direct sale to consumers can schedule maintenance to suit the load and plan shutdowns during the season of low demand, which in northern climates coincides with the period of good weather. This condition is different in the south where, due to the rapid rise in summer air conditioning load, peaks are now experienced in the summer and maintenance must be undertaken in winter under less favorable weather conditions.

In the pulp and paper industry operation of the steam and electric power plant must be subordinate to the manufacturing operations, and plant maintenance is usually scheduled to suit operation of the mill without consideration of the weather. Since outage of the power plant or parts of it may result in curtailment of manufacturing operations, the cost penalty for interruptions in maintenance due to weather may be considerable.

Maintenance of small equipment in an outdoor station is not difficult. In fact, one large chemical manufacturer claims that maintenance costs less for equipment installed outdoors than for the same equipment installed indoors. The reason given for this is that indoor equipment is generally repaired or overhauled on the spot in crowded locations where there is neither room nor facilities for efficient work; whereas the outdoor equipment is disconnected and removed completely to the machine shop where it is repaired or overhauled under the best working conditions. It is claimed this results in lower over-all maintenance costs.

On large equipment, such as the steam turbine and generator, repairs must be made on the spot. A large variety of rigs, tents, and portable shelters have been devised to allow maintenance and inspection during bad weather. Sometimes permanent hoods are used with removable sections. More popular is the rigid frame covered with canvas which can be moved on and off by the station crane. With all types of shelter there is the problem of removing the heavy sections which must be handled by the crane without exposing critical parts to the weather.

In the pulp and paper industry where continuous service is important the over-all economy of outdoor installations should be critically analyzed with full cognizance of the seriousness of prolonging an emergency shutdown due to bad weather where adequate reserve capacity is not available.

### ERECTION

The erection of an outdoor plant can be expected to take longer than erection of an indoor unit. Temporary shelters can be set up so as not to stop work in bad weather but regardless of the means taken for protection of the work some delays are inevitable. Temporary shelters have been erected over boilers to allow insulation work to continue throughout bad weather and removed after erection.

Some kind of portable shelter is necessary for erection of the turbine. This shelter must be removed every time heavy parts need handling by the overhead crane. A light crane on wheels is commonly used inside the portable shelter for handling light parts. All these features cost money and should be charged against the saving in first cost from omitting the building enclosure.

The value of time lost in erection due to bad weather depends on variables beyond the scope of this paper.

### COST OF TYPES OF ENCLOSURES

Graphs have been presented illustrating the relation of the cost of building enclosures to the total cost of a

*Fig. 8. West Springfield station, Western Massachusetts Electric Co.*

**Table I. Plant Cost Analysis**

| | Base open type | Additions or deductions: Minimum enclosure | Fully enclosed type | Insulated type |
|---|---|---|---|---|
| Plant I. Cost per Kilowatt of Manufacturer's Rated Capability (200,000 kw.) | | | | |
| Structural | $14.36 | $1.48 | $1.56 | $2.50 |
| Bldg. service | 0.53 | 0.31 | 1.65 | 1.56 |
| Lighting | 0.88 | 0.07 | 0.27 | 0.27 |
| Electrical | 9.32 | −0.52 | −0.50 | −0.50 |
| Mechanical | 86.52 | −0.94 | −0.96 | −0.96 |
| | $111.61 | $0.40 | $2.02 | $2.87 |
| Plant II. Cost per Kilowatt of Manufacturer's Rated Capability (250,000 kw.) | | | | |
| Structural | $8.88 | $2.06 | $2.21 | $2.83 |
| Bldg. service | 0.66 | 0.05 | 0.85 | 0.78 |
| Lighting | 0.86 | 0.02 | 0.29 | 0.29 |
| Electrical | 11.09 | −0.42 | −0.40 | −0.40 |
| Mechanical | 83.27 | −0.71 | −0.69 | −0.69 |
| | $104.76 | $1.00 | $2.26 | $2.81 |

Costs are for building area only—no yard items included. Top charges included but no contingencies.

power station and it has been noted that some of the savings from reducing the building enclosure are offset by special treatment of equipment exposed to the weather. It is only natural that the question be asked: What items cost more if located outdoors and how much is the net saving in first cost for an outdoor plant? An analysis made last year* of the cost of building enclosures for large central power stations compared incremental costs of structural, building service, lighting, electrical and mechanical items which would either be increased or decreased by the extent of the building enclosure. Table I shows the costs of two stations, arranged as additions or deductions. Using outdoor type as a base, incremental differences are listed for minimum enclosure, fully enclosed low cost construction and fully enclosed insulated type of building enclosure:

In developing comparative costs three criteria have been assumed:

1. *Outdoor Construction.* There should be no enclosures except for the space where the operators spend the major part of their time.
2. *Minimum Enclosed Construction.* The major components must be enclosed for equipment protection and facility of maintenance. Provision for operator comfort should only be extended to the space where the operators spend the major part of their time.
3. *Conventional Enclosure.* The major components must be enclosed and all enclosed space should be treated as working space, suitably heated and ventilated for operator comfort.

* "Economic Factors in Design of Power Station Enclosures," by F. W. Argue, engineering manager, Stone & Webster Engineering Corp. Presented at the 1953 annual meeting of the ASME in New York City.

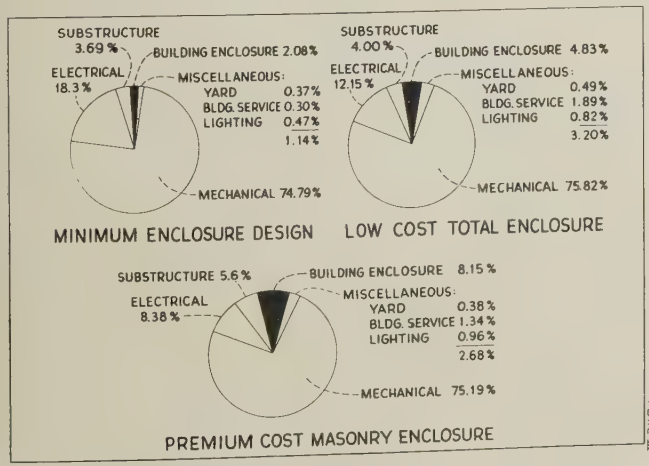


*Fig. 9*

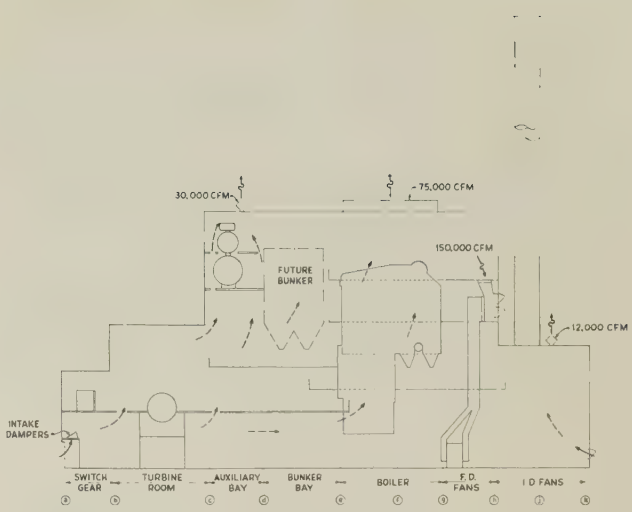


*Fig. 10. Ventilation diagram—industrial power plant*

A further subdivision of the third criterion has been made to take into account complete housing for a mild climate where uninsulated walls would be satisfactory and for a more severe climate requiring insulated wall construction.

The total estimated costs are shown for the portion of plant and equipment affected by building considerations. Thus switchyard, external fuel handling, and similar components are not included.

It is recognized that with smaller plants with higher costs per installed kilowatt of capacity, the incremental costs might be somewhat higher but their proportion to the total cost of the plant should be similar.

It is significant that the fully enclosed low cost type of plant costs $2.02 to $2.26 per kw. more than the outdoor type base plant and the fully enclosed insulated type costs $2.81 to $2.87 more.

## SUMMARY

In summarizing the data just presented it is noted that types of outdoor power plants have been constructed for continuous operation in all parts of the country. The operating and maintenance record is not conclusive and it is hoped that complete data will be published in the future to assist the planner in deciding the scope of the building enclosure. Continuity of operation of prime equipment, the speed of erection, and the duration of unscheduled outages are not subject to the same cost evaluations between the utilities and the pulp and paper industry. The additional cost of a fully enclosed plant over an outdoor plant is about $2.00 to $3.00 per kw. of installed capacity. Any saving resulting from omission of part or all of the building enclosure must be weighed against the many factors applicable to the specific installation which are variables of climate, type of manufacturing operation, plant capacity, and intangible items, all of which should be the subject of engineering analysis and evaluation.

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# Screening of Sulphate Pulp

W. M. EBERSOLE and W. B. SIMMONS

**A brief description of the pulp screening system at Macon Kraft Co. The methods used for consistency control and screen loading are also outlined. Uniform consistency, high loading of screens, rescreening the accepted stock from the primary screens, uniform shower water pressure and a centralized control panel contribute to a dependable delivery of consistently clean and uniform stock.**

WHILE the Macon mill was in the design stages the operators asked that they be allowed to assist in making the plans for stock screening.

It was granted, and discussions were held. A system based upon the collective experience of the operators was agreed upon for installation. The objectives were: (1) maximum capacity per screen, (2) occlusion of all air, (3) uniformity of operation, (4) maximum cleanliness for type of screen selected, (5) centralized control and maximum ease of operation, and (6) positive control of weight (tons per hour) and consistency to the screens, and this to not be affected by varying water pressures on showers inside the screen.

The basic pieces of equipment selected were: Impco no. 4 screens, a mixing pump, a consistency controller, and a weight regulator. Other items included necessary pumps, pressure controls, remote operators for valves, and a distribution box to the screens which was designed and fabricated for the particular job.

The purpose of this paper is to give an outline of this particular screening process, starting with stock in the washed stock chest, and ending with stock in the deckered stock chest.

Stock is drawn from the washed stock chest at 4% consistency and pumped to the suction of the screen dilution pump (i.e., fan pump) (Fig. 1). The consistency of this stock is maintained by a Trimbey regulator at 3.55%. The amount of stock to the dilution and mixing pump is controlled by a regulator, with overflow, similar to the conventional weight regulator set up for a paper machine.

The controlled consistency and regulated weight of stock is introduced to the suction of the screen dilution pump which takes suction from the decker filtrate pit. The capacity of the mining pump is ample enough to handle the stock and sufficient water for dilution to the desired screening consistency.

The consistency to the screen headbox averages in the neighborhood of 1.4 to 1.5%, and control of this final consistency is obtained by throttling the discharge of the dilution pump.

It should be pointed out that this system of stock control and final consistency is very similar to the weight and consistency control used on a paper machine.

Stock moves from the fan pump to the distribution box and enters each end of the screen distribution box (Fig. 2). The distribution, or headbox, is designed similar to the cross flow inlet to a paper machine headbox with the exception of the tapered cross-section area. The area is reduced after each screen to maintain the same horizontal velocity to prevent settling out. Stock can be delivered to any or all of the primary screens by means of air operated valves whose controls are located on a central panel board.

Primary screening is accomplished with seven Impco no. 4 centrifugal screens operating at 360 r.p.m. with 75-hp. motors. The holes in the screen plate through which the accepted stock passes are 0.110 in. in diameter.

Each screen is equipped with six fresh water showers. The four top showers operate at 10 p.s.i. pressure and the two bottom showers operate at 35 p.s.i. pressure. The pressure on the showers is constant and is maintained by means of a booster pump, pumping through a pressure regulator. There is no doubt that the maintenance of constant pressure on these showers is a large factor in cleanliness of the stock. It also helps make possible operation of the screen at maximum load without danger of overload.

Ammeter readings on each screen drive give a good indication of the stock load being delivered to each screen. These ammeters are located on the central control panel. By using the ammeter readings and the air-operated control valves, the operator controls the loading to each screen.

It has been found that to get optimum screening, each screen should be run at the highest load possible. It is the policy to avoid operating any screen at part load. Most of the time three screens take care of a load of 700 to 750 tons per day. A change in hardness or permanganate number of the stock, or an increase of rejects in the stock, will necessitate the operation of additional screens, but, whatever the circumstances,

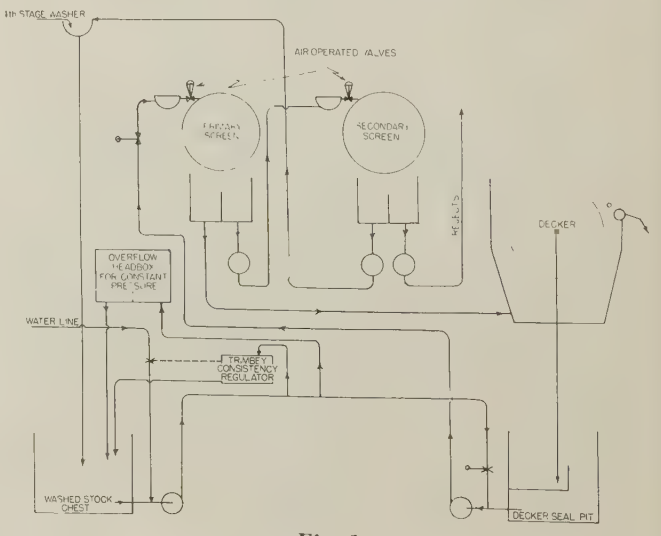



*Fig. 1*

W. M. EBERSOLE, General Superintendent, and W. B. SIMMONS, Chief Chemist, Macon Kraft Co., Macon, Ga.

the number of screens operating is kept at an absolute minimum.

The primary screens are operated in such a manner that the outlet is at maximum cleanliness even though the rejects contain a high percentage of acceptable stock; higher than could be tolerated without generous secondary screen capacity.

The rejects from the primary screens, at approximately 2.5% consistency, are diluted and pumped directly to the headbox of the three secondary screens.

The secondary screens are identical to the primary screens.

The purpose of these secondary screens is to rescreen the tailings from the primary screens to remove all acceptable stock. As has been previously stated, the rejects from the primary screens contain a high percentage of acceptable stock, but this is not an objectional feature and presents no subsequent problem for the secondary screens as adequate capacity is available. Seldom have more than two secondary screens been used; three are installed, leaving one down. Screens in use are rotated so that each screen is taken down once each week for cleaning and inspection.

Unlike the primary screen, the secondary screens are operated for maximum cleanliness of the tailings, that is, freedom of stock from the tailings. Dilution is high and the screen, or screens, are operated under rated capacity. This means that the accepted stock from the secondary screens contains considerable shives. The accepted stock from the secondary screen at 0.4% consistency or less, instead of being run over the deckers, is used for part of dilution from the last stage washers and is subsequently rescreened in the primary units.

The accepted stock from the primary screens, slightly over 1% consistency, flows by gravity to two deckers, where it is thickened for delivery to the deckered stock chest.

These are 8 by 16-ft. Impco deckers, covered with 40-mesh stainless steel facing wire. The deckers operate at 9 in. vacuum and are driven by variable speed d.c. motors.

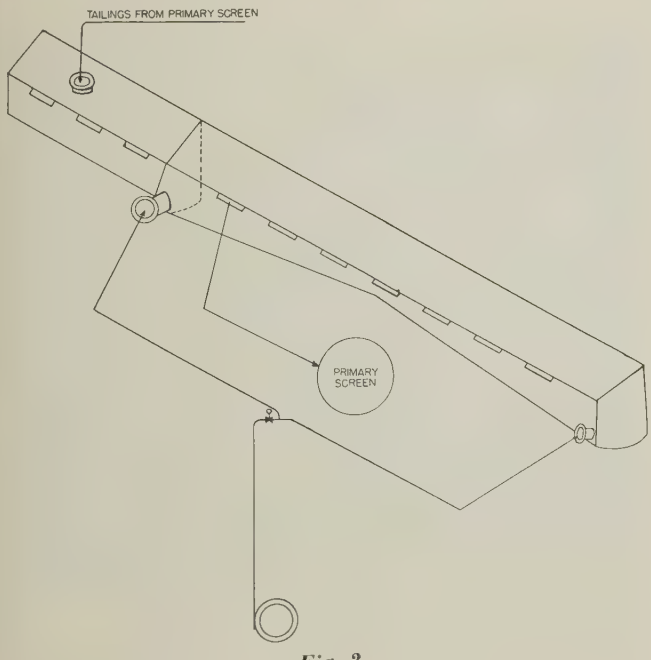



*Fig. 2*

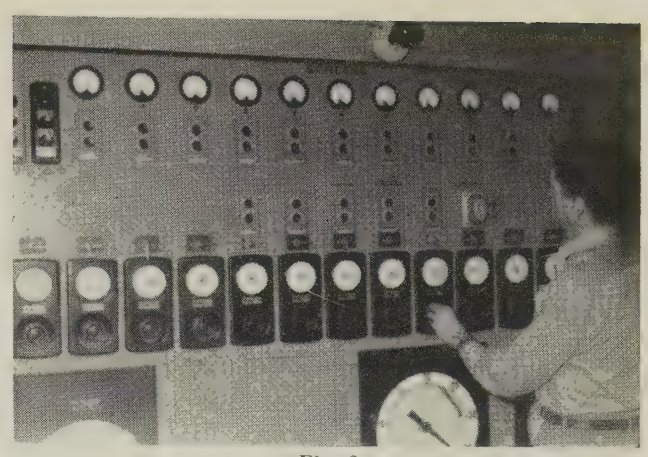


*Fig. 3*

Paper machine white water is used for the cutting, or knockdown, showers on the deckers. These are kept fully open during operations, but do not furnish sufficient water for dilution to the desired deckered stock chest consistency. The remaining dilution water is added by means of a controller taking its primary impulse from the load of the principal chest agitator. The consistency of the deckered stock chest is controlled at 3½%, and is recorded and regulated at the central control panel in the screen room.

One feature of the screen room that makes for efficiency of operation is the centralized control panel (Fig. 3). The following recorders and controls are found on this panel:

1. Push buttons for all pumps, screens, deckers, and chest agitators.
2. Ammeters showing load on each screen.
3. Remote controls for positioning air-operated valves, regulating volume being delivered to each of the separate screens.
4. Reconsider and controller for pressure on screen shower water.
5. Decker chest consistency regulator controller and recorder.
6. Decker chest level recorder.

This panel is so complete that one man operates the screen room from this board. To further promote efficient operation, the valves regulating water and stock being delivered to the primary screens headbox are controlled from the same area.

Summarizing, the following general notes are presented:

1. Stock coming from the screens is consistently clean.
2. The space required to house the screens and deckers is small, and as installed, presents a neat and orderly arrangement.
3. The capacity and efficiency of each unit is high. It has previously been stated that most of the time only three primary screens are required to do the job of screening 700 to 750 tons of stock per day.
4. Conditions do not have to be ideal in order for the screens to operate efficiently. They will do an effective screening job on stock with a low or high permanganate number, or on stock that contains a high percentage of rejects.
5. With a centralized control panel, screens can be operated with a minimum of effort on the part of the operator.

6. There is no foaming from these screens, and at no time has a de-foaming agent, such as kerosene, been used.

7. Much of the over-all good efficiency of these screens can be attributed to the following factors: (a) uniform consistency in the screen headbox, (b) high loading of the primary screens, (c) rescreening the accepted stock from the secondary screens, (d) uniform shower water pressure on the screens, (e) a centralized control panel, and (f) more than the minimum theoretical number of screens for the contemplated tonnage was installed. This was not an accident. Spare screens assure that all screens can be kept in top notch condition at all times with only minor adjustments and repairs, thus minimizing chances of plate breakage and any need for major repairs. Each of the screens is opened, cleaned, inspected and any needed repairs made at some time during the week. Consequently, the screen room is never "behind the eight ball." The paper mill has never lost time or had to slow down because of screening difficulties.

In conclusion, it is believed that the system has done a good job of screening under varied conditions with dependable delivery to the paper mill of consistently clean and uniform consistent stock.

RECEIVED March 12, 1954. Presented at the 39th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 15–18, 1954.

# Paper Mill Rehabilitation Involving Rebuilding Old Paper Machine Versus a New Machine

JOHN A. McPHERSON and HAROLD G. INGRAHAM

**This presentation concerns itself with the manner in which Mosinee Paper Mills Co. went about rebuilding a paper machine. This was no ordinary rebuild job, since it required complete removal of the entire machine and restoring it as a modern high-speed production unit. The first part of this discussion describes the reasoning behind certain basic decisions and what prompted management to authorize rebuilding a machine versus installing a new one. The authors describe and compare the advantages and disadvantages of one over the other and how these features influenced the final decision to rebuild the existing machine. In the second part of this presentation, some interesting phases of job organization and job management are described and how certain difficult construction problems were overcome before and during the actual shutdown for rebuilding. Details of advance planning are given, also the logistics of handling machine parts and construction materiel during a highly concentrated period of construction activity.**

MANY articles about pulp and paper mill expansion and modernization programs have been published by the trade magazines during the past several years. These articles have invariably described in detail the physical engineering details such as electric power generating facilities, water and steam distribution systems, materials handling, buildings, the paper machine and its auxiliary equipment, and who was responsible for what are all listed and credited. Seldom, however, can we find in print the reasoning behind certain basic management decisions. Why were things done the way they were? What, for example, prompted management to authorize the rebuilding of a paper machine rather than the purchase of a new one?

The responsibilities of management are manifold and two primary administrative functions are the effective control of current operations and the planning of future operating methods and facilities. The planning function is of paramount importance. The over-all objectives of the organization must be formulated as a guide for departmental current and long-range programs. Forecasting and planning physical requirements and equipment utilization as well as planning for process and product research and development are dependent on long-range objectives. Whenever possible, it is advisable to convert these objectives to quantitative terms. The goal of every manufacturer is, of course, to make a better quality product and to constantly improve and increase production in order to provide a better return to his stockholders, a higher income to his employees, and better values at lower cost to his customers. The major yardstick for action on a modernization program is, therefore, profitability, predicted and attained. The final decision rests on the economics of the program. A well-known industrialist once stated in simple terms that the way to make a profit was to spend less than you take in. What he well knew, however, was that he had to *continually* spend money for modernization of his plants in order to insure that profit.

A paper machine is probably better adapted for economic survival than most of man's tools. The reason for this may stem from the fact that its owners can survive competition in the industry by shifting grades to higher values. Upgrading has been the reason for the survival of many manufacturers. Eventually, however, even though grade shifting has maintained or even improved an economic position, the time comes when the machine must be replaced by a new one or be rebuilt to modern standards to permit the mill to improve its relative position in the industry. Modernization expenditures can result in highly efficient machine operations. Quality production on new or on modernized machines is reaching surprisingly high levels, so high in fact, that these machines when operating on a continuing grade can approach the theoretical product of trim times speed times basis weight for making paper 24 hr. per day for 350 days per year.

In evaluating the economics of added productive capacity, management looks to the sales department

JOHN A. MCPHERSON, Mosinee Paper Mills Co., Mosinee, Wis., and HAROLD G. INGRAHAM, Chas. T. Main Inc. Boston, Mass

to provide an estimate of the volume and grades of additional tonnage of product that can be marketed. Market analysis in accordance with sales requirements will reveal possible alternatives of developing present markets more intensively or cultivating new markets. The rapidity with which markets and marketing methods today are changing presents acute problems that tie in directly with productive requirements. In any event the market analysis is a basis for the decision to increase the production of present grades or to add new products or both. It is, therefore, assumed that prospective future sales warrant the additional tonnage, and the type of product guides the selection of equipment.

At this point, management must consider whether or not the cost of obtaining this additional tonnage can be justified. Again a number of questions arise which require careful analysis. It is obviously unwise to create future charges for capital services beyond a certain point. What is this point? How will new fixed charges be absorbed on the paper machines? What is the effect of additional tonnage on other facilities and other productive equipment? What is the effect of an increased hourly return from increased speeds in the event of a sales drop of 10 or 20% and curtailed operations or a shorter working week? This analysis can very well indicate a greater hourly return on the new investment during curtailed than during full operations. In addition, what is the working capital requirement to maintain the proposed sales volume? What is the financial plan? What is the effect of the proposed plan on financial results; on financial resources; on financial requirements? In other words, reports are necessary. Financial, statistical, economic, and rate of return before and after taxes studies should be made. Capital investment above depreciation accrual must be predicted on as much factual information as possible. Before any of these questions can be answered an engineering survey, analysis, cost estimate, and complete project report are necessary to provide management with the basic figures with which to act.

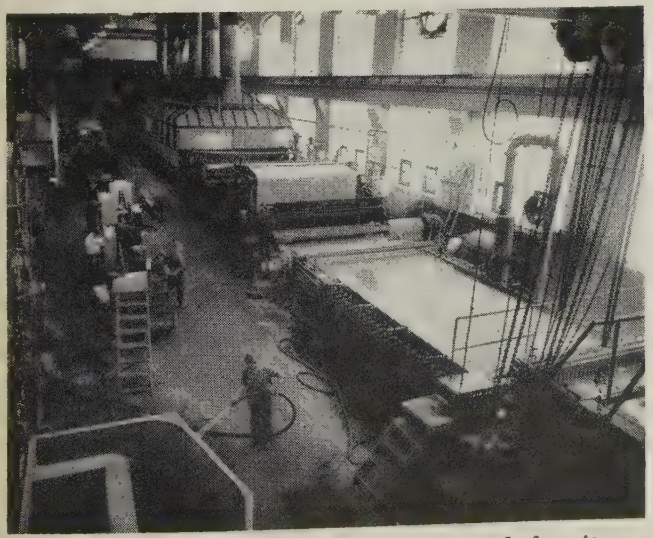


*Fig. 1. No. 1 machine at Mosinee the day before it was shut down for rebuilding. No. 2 machine at the left operated at full capacity without loss of production during the shutdown period*

*Fig. 2. View of no. 1 machine from the dry end taken the day before shutdown for rebuilding*

All the foregoing considerations, and additional data where necessary, will indicate the kind of thinking and the sequence of events which will transpire in varying degrees in any mill where additions to its pulp and paper productive capacity are under consideration.

This was the sequence of events at the Mosinee Paper Mills Co. when, in 1952, the management authorized the rebuilding of their no. 1 paper machine to make possible increased tonnage, a still higher quality product, and further grade diversification.

This mill is one of the pioneer sulphate mills in America and, in fact, in the world. Located in the heart of Wisconsin on the hard-working Wisconsin River, it is one of the first mills built from the ground up for the sulphate process. Operations began in 1910 and Mosinee has successfully met the competition of the more recent and modern big mass-producing kraft mills by specializing in the high quality industrial specialty field. A postwar modernization program initiated in 1946 and costing in excess of $5,000,000 has resulted in many economies and has provided facilities for the increased production of high quality pulp and paper. The Mosinee operation includes a fully integrated woodlands, pulp and paper operation, and some provision for conversion. Three paper machines, with maximum trims of 125, 104, and 101 in., produce a wide variety of specialty grades at a former daily production rate of approximately 140 tons.

An engineering report in 1951 indicated that the maximum capacity of pulp and paper mill facilities, other than the paper machines, was sufficient to sustain a paper production of 165 tons per day of grades normally made on the three paper machines. Beyond this apparent break point, an expenditure of considerable magnitude would have been required for necessary additions to the pulp mill, chemical recovery, steam, power, and stock preparation departments to maintain an economical mill balance between pulp and paper. Beyond this 165-ton limit was a secondary limit of 200 tons with any further addition for still higher productions at a considerably increasing rate. On this basis, pulp mill facilities in departments where expansion took place were selected on a 200-ton production rate.

*Fig. 3. View from the same position as Fig. 2 four days after shutdown. Machine is completely removed, old drier pit is being removed and new baseplates are being set*

It was seen from an analysis of the engineering report that when operating the pulp mill at its full potential at that time, there would be a surplus of pulp sufficient to sustain another 25 tons of paper per day. The logical machine to absorb this pulp surplus was no. 1, since earlier machine modernization had been made in nos. 2 and 3 machines. These modifications and additions had resulted in a quality improvement, increased production, and more flexible operation. The work was done at a relatively low cost and with a short down time during alteration.

Modernization of no. 1 machine, however, was an entirely different matter. It is one thing to add a few driers, a size press, and/or miscellaneous parts to a machine, but quite another when you make what amounts to a new machine out of an old one.

Prior to rebuilding this then 123-in. trim machine produced an average of about 60 tons per day of creped and flat specialty papers. Although maintained in the best possible mechanical condition, the machine had a safe maximum speed of 800 f.p.m. In actual production it seldom reached this figure because of limitations imposed by formation on the wire, drying capacity, creping variation, and the like. The driers had been cast and machined in the days when trueness and surface finish were not too important and drier pressures were limited to operation at moderate speeds, entrained air and slice problems prevented good formation and a level sheet at higher speeds, and the reel and winder were totally inadequate to handle the proposed tonnage. In order to produce 85 to 90 tons of paper per day a maximum speed of 1200 f.p.m. would be required. Thus, with this estimated speed plus the other machine deficiencies, it is small wonder there was an inclination at first to avoid spending a lot of money on the machine.

The alternate consideration was, of course, to install a new paper machine. The tonnage requirements above the production rate of the other machines would be in the neighborhood of another 100 tons per day. This was considerably beyond the productive capacity of the pulp mill with even further major expansion in those departments. Estimates showed that the cost of such a major pulp mill expansion program could not be justified. In addition, an apparent sales volume at that time could not provide an immediate market for the estimated production and would consequently not allow productive operation of the old and new machines. An alternative of shutting down one of the two older and narrower machines having speeds and trims adapted to small orders of specialty papers was not advisable. The papers produced and the trims sold on the existing machines were tailored for customer requirements and any radical change in any machine or the substitution of a new machine would bring corresponding difficulties in producing papers for a very particular specialty market. Thus, it was in many ways more advantageous to utilize as far as possible existing equipment.

It was agreed that a new machine would have certain advantages over a rebuilt one for the simple reason that it could be selected for many features considered advantageous in the experience of the operators. Thus press sections, creping, size press, and all features could be tailored to the requirements of the principal grade produced. (Again, however, we realize that today's principal grade can be obsolete tomorrow.) In addition, a new machine could be installed without interruption of production. It could also be made to run at higher speeds than a rebuilt machine.

In the final analysis, considering the cost of a new machine, its auxiliary equipment, building additions, and pulp mill expansions, as well as the problems arising from marketing and other considerations, it was decided that no. 1 machine should be rebuilt. It was the considered opinion that the machine speed could be increased to 1200 f.p.m. Beyond this speed many otherwise usable machine parts would have had to be scrapped and new ones substituted.

After the decision to rebuild was made, consideration was given to such subjects as how the job could best be handled, who would do it, how long a down time, and similar questions. Regardless of how large and capable a construction crew a mill may have, few mills are prepared to undertake even a moderate size machine rebuild without help. Ordinary mill repair and main-

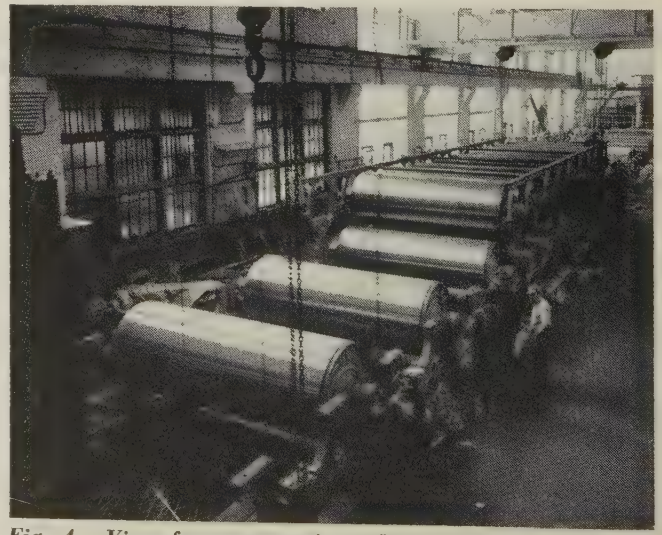


*Fig. 4. View from approximately the same spot as in Figs. 2 and 3, taken 18 days after shutdown. The driers have been trucked to Beloit Iron Works shops, 150 miles distant, for turning and grinding. Also the journals have been remachined and fitted with antifriction bearings*

tenance work cannot be neglected during the shutdown period. On the contrary, this work must be accelerated to insure continuous operation at maximum production for all units not involved in the shutdown. Usually high-class millwright talent of the specialized type required for exacting paper machine erection requirements is not readily obtainable outside the mill. The fact that such talent was available in this particular case influenced the decision of when and how to do the job.

After many months of the most elaborate planning, after weighing in advance every conceivable problem that might arise before, during, and after the rebuild, executive approval was given to proceed with the work.

The sequence of events and reasoning of the management of the Mosinee Paper Mills Co. in deciding to rebuild their no. 1 paper machine instead of purchasing a new one having been outlined, let us take a look at the manner in which the actual work was carried out.

A detailed description of the job would be too long and boresome to discuss here. Some time ago, at another conference, a speaker said, in referring to statistics that they are more efficient than any sleeping pills. There are, however, a few interesting features about the way certain problems were successfully solved at Mosinee to warrant presenting at this time.

The difficulty of obtaining a sufficient number of talented and capable millwright and construction workers for a major paper machine rebuild, such as they contemplated at the time has been mentioned. This problem, happily, was overcome by the following situation.

It so happened that a neighboring paper mill was installing a new machine about the time Mosinee was considering a no. 1 machine rebuild. The installation labor was being furnished by an outside contractor who had, months before, assembled a trained staff of paper machine erection specialists and construction personnel. Coordination of the two jobs was worked cut in a manner to the benefit of both mills. The date of the Mosinee shutdown of no. 1 machine for rebuild was scheduled to coincide with completion of the neighboring mill's new machine installation. It was believed that, with another job in sight, construction workers would be inclined to work at top efficiency on the one job to its completion if they knew they were to be shifted without lost time to another job. It was proposed to have the men absorbed, a few at a time, into the Mosinee maintenance and construction crews doing work in preparation for down-day. Before this apparently ideal labor situation was devised, a meeting had been arranged with labor union leaders representing seven separate crafts whose workers were involved. At this meeting mill officials explained to them the proposed rebuild construction schedule which was originally set up on a continuous round-the-clock basis. The group were advised that it would be necessary for them to absorb into their respective crews all of the mill help that would be assigned to the rebuild job even though their pay scales were different for the same kind of work. A written agreement to this effect was made and signed by all. The only change from the mill proposal was a request that the men work two 10-hr. shifts instead of three 8-hr. or two 12-hr shifts. They reasoned that a man coming off a shift at 3 a.m. has a better chance of sleeping if he gets to bed while it is still dark than he would if he worked until 6 a.m. The hours agreed upon were 6 a.m. to 4 p.m. and from 4 p.m. to 3 a.m. Each week-end the shifts changed. Those working on the night shift were given premium pay of 1 hr. at the prevailing rates.

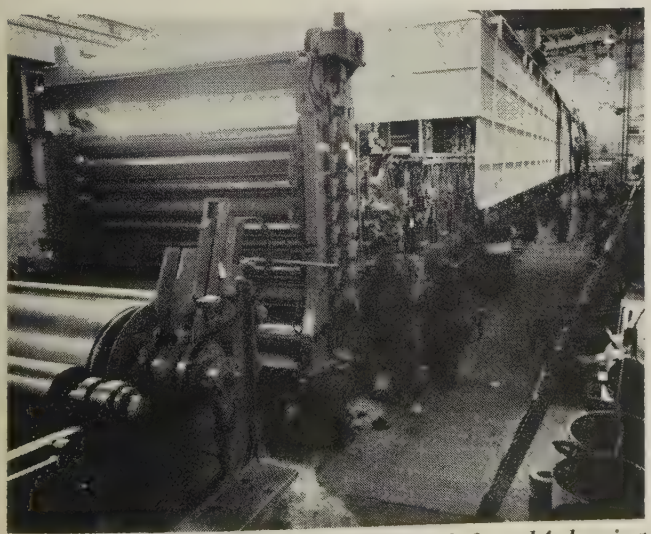


*Fig. 5. Picture from same spot as Figs. 2, 3, and 4 showing machine nearly ready to run 30 days after its complete removal from foundation. Note new hood being painted*

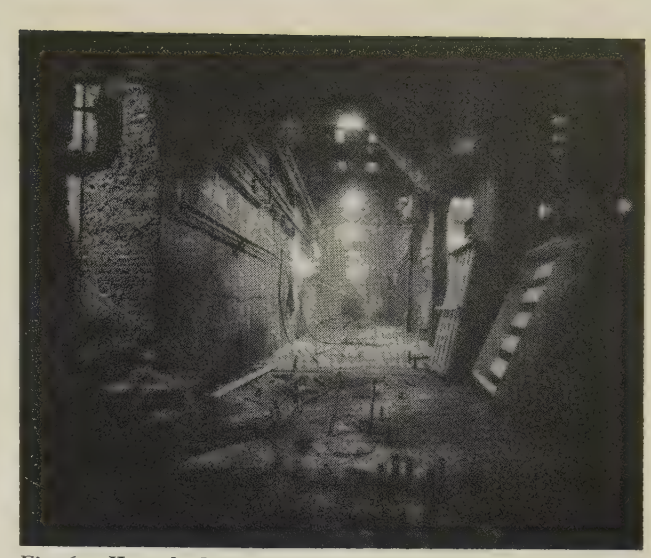


*Fig. 6. How the basement looked 4 days after the machine was shut down. All old line shaft piers have been removed, as well as steam and condensate piping*

As finally drawn up, the specifications of the rebuilt machine called for an entirely new fourdrinier, including the latest type air-cushioned inlet and headbox. The press was to be modified to provide room for additional driers and for installation of a new type inverse suction second press. New driers were to be added and the old ones trucked to the machine builder's plant some 150 miles away for regrinding, balancing, and remachining of the journals to fit new antifriction bearings. The existing calender stack required moving forward to allow for additional driers. A new reel and winder and all new drives were needed. Other work, on the machine itself, consisted of a new paper machine hood and machine room ventilating system, installation of new drier drainage, air impingement and moisture control systems, new vacuum and water pumps and piping, and

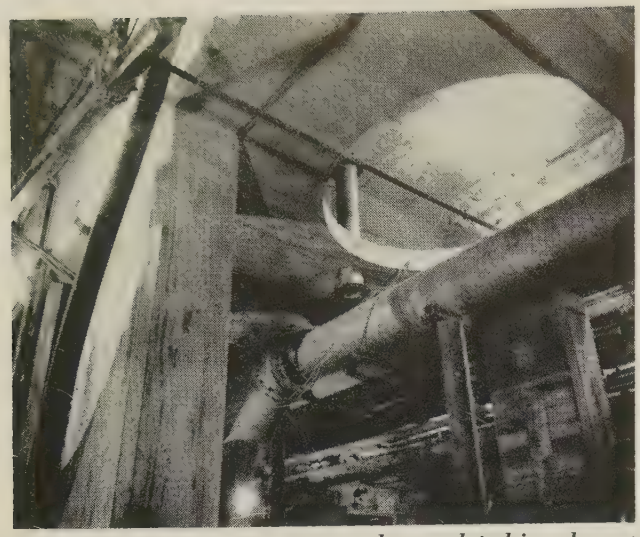


*Fig. 7. Preparatory concrete work completed in advance of down-day. A new concrete wire pit was constructed underneath the old one while the machine was running. Concrete was placed by the Intrusion-Prepakt method of pumping high bond strength concrete into the forms under pressure. Calender foundation and floor beams on back side were similarly constructed*

completely new instrumentation and electrical controls. A battery of 32 centrifugal pulp cleaning devices, one of the largest of its kind, was proposed to be close-coupled to the headbox through an intricate system of large diameter, light gage, stainless pipe which was prefabricated to exact dimensions. Such a comprehensive machine rebuild required an equally ambitious construction program for its complete success. Some of the preparatory work could be done beforehand but the major part of it had to be completed within a few weeks' period immediately following down-day. All old line shaft piers must be removed and new ones built, the floor on the back side needed strengthening, and hundreds of smaller but still important jobs needed to be done, somehow, within the allotted time. Two very essential modifications in prospect were the construction of a new tile-lined wire pit and sump and a new foundation for the calender stack. The wire pit had been designed to minimize air entrainment ahead of the fan pump. Its complicated shape and the problem of having to bond new concrete with old while the paper machine was operating required an entirely new construction approach. A similar situation existed in the case of the calender foundation. Both problems were neatly overcome by adoption of the Intrusion-Prepakt method of concrete placement. Forms were prepared and jacked up tightly underneath the existing concrete. Into these forms high-bond-strength concrete grout was pumped under pressure, filling all voids. These operations were completed well in advance of down-day.

The logistics of materials handling during the shut-down period is worthy of note. Emphasis was placed on bringing these items to the worker at the exact time and place when needed. This involved a carefully arranged schedule to insure maximum efficiency from skilled and high-paid construction workers. These were assigned to definite working areas within which they had to stay until relieved. Frequent meetings of construction leaders kept schedules adjusted in order to maintain continuous progress on each individual assignment. Machine parts, tools, and construction materials were handled to and from these work centers by transport crews equipped with electric trucks.

**Table I. Per Cent of Total Cost of the Major Items**
Note that the cost of paper machine parts plus cost of auxiliaries is exactly 50% of the total

| | *Per cent of total cost* |
|---|---|
| Paper machine (parts only) | 40.0 |
| Labor erecting paper machine | 13.1 |
| Labor erecting auxiliaries | 11.0 |
| Auxiliary apparatus | 10.0 |
| Electrical (includes instruments) | 5.4 |
| Piping (includes special valves) | 4.7 |
| Structural | 5.2 |
| Miscellaneous (freight, insurance, etc.) | 2.6 |
| Engineering and construction management | 8.0 |
| | 100.0 |

Identifying each one of the thousands of new and used machine parts was a special problem in itself. Parts to be re-used needed cleaning, painting, and some needed repair. Other parts were scrapped. A large warehouse served as a collection center. The floor of it had been divided into numbered and lettered squares in which parts in transit were stored temporarily. A master chart indexed with the description of parts in each square was tied in with a drawing to show where each part was located on the paper machine. Parts to be cleaned were loaded on to railroad flat cars and stored in the mill yard waiting their turn to be pulled into the locomotive round house. Here special crews equipped with high pressure chemical cleaning apparatus removed grease, oil, and scale in a few minutes.

It is difficult to imagine that the best way to rebuild a paper machine is to lay it flat and then begin again from the foundations, but that was the exact procedure. Within 48 hr. after the machine was shut down nothing was left of it but the concrete machine tracks. Even the baseplates had been torn up and a gang of concrete breakers were taking out the old wire pit under which the new one had been built while the machine was operating.

In 6 weeks from down-day the machine had been completely re-assembled, painted, and made ready to run. A new hood and ventilators were in place, new floors had been laid, all new stock preparation and auxiliary apparatus had been installed with all piping, wiring, and instrumentation. It was truly a remarkable achievement, especially considering that all of this took place within a few feet of another paper machine, which, meanwhile had been operating without loss of production. Normally a program of this kind would have taken 4 to 5 months to complete on a straight time basis. Good job organization, good job management, and the high efficiency of excellent labor sustained by the incentive of high take-home pay made it possible to do the ultimate in paper machine rebuilds in record time. The penalty for speed is high initial cost. The rewards come in getting the machine back into production. The decision to rebuild an old machine or install a new one must be judged on the merits of each individual case—there is no formula to use as a guide. In this case history just described it is paying off.

RECEIVED Aug. 25, 1954. Presented at the Ninth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., Oct. 18–21, 1954.

# ASSOCIATION NEWS AND EVENTS

## *TAPPI Conferences*

Eight fall conferences of the Technical Association of the Pulp and Paper Industry are in preparation:

**Fourth Statistics Summer Course**

Forest Products Laboratory, Madison, Wis., July 10–23, 1955.

**Fifth Fundamental Research Conference**

The Institute of Paper Chemistry, Appleton, Wis., Sept. 15–17, 1955 ("Fundamentals of Bleaching").

**Second Mechanical Pulping Conference**

Poland Spring House, Poland Spring, Me., Sept. 19–21, 1955.

**Sixth Testing Conference**

Hotel Sheraton Kimball, Springfield, Mass., Sept. 28–30, 1955.

**Ninth Alkaline Pulping Conference**

Hotel Patten, Chattanooga, Tenn., Oct. 19–21, 1955.

**Eleventh Agricultural Fibers Conference**

Alton, Ill., Oct., 1955.

**Tenth Engineering Conference**

Rice Hotel, Houston, Tex., Nov. 7–9, 1955.

**Tenth Plastics-Paper Conference**

Brooklyn Law School, Brooklyn, N. Y., Nov. 14–15, 1955.

## *Forty-First Annual Meeting*

The 41st Annual Meeting of the Technical Association will be held in the Commodore Hotel, New York, N. Y., on Feb. 20–23, 1955. Individuals and companies desiring to present papers at this meeting should write to the Secretary of TAPPI, 155 E. 44th St., New York 17, N. Y.

## *Tenth Paper-Plastics Conference*

The Tenth Paper-Plastics Conference will be held at Brooklyn, N. Y. (probably in the Brooklyn Law School) on Nov. 14–15, 1955.

Two sessions have been scheduled; one under the chairmanship of Herman Mark of the Polytechnic Institute of Brooklyn, which will deal with new types of resin for laminates; and the other on general papers dealing with laminates, under the chairmanship of Paul Goodloe of the Brown Co., Berlin, N. H.

## *Process Instrumentation and Control*

Process instrumentation and control is being extensively used in the paper industry. For this reason the TAPPI Engineering Division is sponsoring a new committee to deal with this important subject. The committee will serve as a clearing house for reporting the latest advances in the use of instruments to improve quality and to lower costs. The committee will hold its first meeting at the Tenth Engineering Conference to be held at the Rice Hotel, Houston, Tex., on Nov. 7–9, 1955.

Efforts are now being made to organize a committee to deal with the subject of operations control from the engineering standpoint. Employees of companies that are actively interested in the application of instrumentation and control are invited to serve as members of this committee which is being sponsored by the TAPPI Engineering Research and Machine Design Committee. Managers of companies and persons interested in participating in the work of this committee are urged to write to the Secretary of TAPPI, 155 E. 44th St., New York 17, N. Y.

## *Ninth Alkaline Pulping Conference*

Plans for the program of the Ninth Alkaline Pulping Conference to be held at the Hotel Patten, Chattanooga, Tenn., are proceeding at a satisfactory rate.

Malcolm B. Pineo, Brunswick Pulp & Paper Co., Brunswick Ga., chairman of the Alkaline Pulping Committee, has announced that George Koons of the Bowaters Southern Paper Corp., Calhoun, Tenn., is in charge of handling local arrangements and David Wetherhorn, Southern Paperboard Co., Port Wentworth, Ga., is in charge of the technical program.

Associated with Mr. Wetherhorn as moderators of three technical sessions are T. T. Collins, Hudson Pulp & Paper Co., Palatka, Fla.; J. J. Goss, Gaylord Container Corp., Bogalusa, La.; and Vernon Woodside, Olin-Mathieson Chemical Corp., New Orleans, La. There will also be a fourth session devoted to semichemical pulping under the direction of John N. McGovern, Parsons & Whittemore Co., New York, N. Y., chairman of the Semichemical Pulping Committee.

A feature of the conference will be an inspection tour of the Bowaters Southern Paper Corp. mill at Calhoun, manufacturers of newsprint, kraft pulp, and groundwood.

Mr. Wetherhorn has announced that papers on the following subjects have been scheduled for the technical program:

1. The Kamyr Continuous Cooking Process
2. Study of the Cooking of Old Wood
3. The New Foxboro Magnetic Flow Meter
4. The Thermal Conductivity of Black Liquor
5. The Practical Application of Statistical Methods to the Study of Vacuum Washing
6. Polysulphidity
7. New Developments in Cleaning Recovery Boilers
8. Chip Packing Studies
9. Tall Oil Developments

## *Seventh Coating Conference*

The first organization meeting to make plans for the Seventh Coating Conference was held recently in the Association headquarters office in New York. J. T. Loomer, Robert Gair Co., Uncasville, Conn., presided as chairman. C. G. Landes, American Cyanamid Co., 1937 W. Main St., Stamford, Conn., is in charge of the technical program. E. R. Padavic, Container Corp. of America, Manayunk, Pa., will be in charge of local arrangements for the meeting to be held at the Benjamin Franklin Hotel, Philadelphia, Pa., on May 7–9, 1956, and J. C. Rice of the Lowe Paper Co., Ridgefield, N. J., will be in charge of publicity.

The general theme of the conference will be "The Properties and Techniques of Utilizing Synthetic Adhesives for Coating." Plans are being made to provide inspection trips of the plants of the Hercules Powder Co. and of the E. I. du Pont de Nemours & Co. plants.

## *New England*

At its annual meeting held at the Oceanside Hotel, Mag-

nolia, Mass., on June 4, 1955, the New England Section elected the following officers for 1955–56:

*Chairman*—Gordon L. Benson, St. Regis Paper Co., East Pepperill, Mass.
*Vice-Chairman*—C. L. Reese, Westfield River Paper Co., Russell, Mass.
*Secretary-Treasurer*—R. W. Ramsdell, Hercules Powder Co., Holyoke, Mass.
*Executive Committeemen*—
F. S. Klein, Byron Weston Co., Dalton, Mass.
J. T. Loomer, Robert Gair Co., Uncasville, Conn.
Miss H. U. Kiely, American Writing Paper Co., Holyoke, Mass.
John Lewis, Lowell Technological Institute, Lowell, Mass.
F. L. Simons, Crane & Co., Dalton, Mass.
Ronald Mallock, American Writing Paper Co., Holyoke, Mass.
Wm. Stillman, Bird & Son, Inc., East Walpole, Mass.
C. I. Horton, Philadelphia Felt Co., Norwalk, Conn.
E. W. Strecker, Esleek Mfg. Co., Turners Falls, Mass.
P. J. Fitzpatrick, American Cyanamid Co., Boston, Mass.
Richard Dempsey, A. E. Staley Mfg. Co., South Hadley Falls, Mass.

The schedule of meetings for next season is as follows:
Oct. 14–15, 1955, Curtis Hotel, Lenox, Mass.
Dec. 9, 1955, Roger Smith Hotel, Holyoke, Mass.
April 6, 1956, Roger Smith Hotel, Holyoke, Mass.
June, 1956, Oceanside Hotel, Magnolia, Mass.

## *Chicago*

At its annual meeting held on May 9, 1955, the Chicago Section elected the following officers:

*Chairman*—Arthur C. Dreshfield, Chicago Testing Laboratories, Chicago, Ill.
*Vice-Chairman*—M. W. Snover, Williamson Adhesives, Chicago, Ill.
*Secretary*—Kaz Horita, Container Corp. of America, Chicago, Ill.
*Treasurer*—R. L. Ueberbacher, American Maize Products Co., Roby, Ind.

## *Maine-New Hampshire*

The Maine-New Hampshire Section elected the following officers at its annual meeting held at North Conway, N. H., on June 24–25, 1955:

*Chairman*—Arthur E. Jones, Oxford Paper Co., Rumford, Me.
*Vice-Chairman*—Roland J. Martin, Fraser Paper Ltd., Madawaska, Me.
*Secretary-Treasurer*—Harold E. Pratt, Pejepscot Paper Co., Brunswick, Me.
*Executive Committeemen*—
Albert E. Bachmann, Missisquoi Corp., Sheldon Springs, Vt.
C. T. Bockus, Eastern Corp., Bangor, Me.
F. N. Sprague, St. Regis Paper Co., Bucksport, Me.
Henry S. Hooper, Penobscot Chemical Fiber Co., Great Works, Me.
John H. Heuer, Great Northern Paper Co., Millinocket, Me.
Joseph J. Thomas, S. D. Warren Co., Cumberland Mills, Me.
Jack F. Wright, National Aniline Div., Boston, Mass.
Paul M. Goodloe, Brown Co., Berlin, N. H.
Andrew J. Chase, University of Maine, Orono, Me.
Edward N. Poor, Hudson Pulp & Paper Co., Augusta, Me.

## *Ohio*

At the annual meeting of the Ohio Section held at the Hartwell Country Club, Cincinnati, Ohio, the following officers for 1955–56 were elected:

*Chairman*—William H. Aiken, Gardner Board & Carton Co., Middletown, Ohio
*Vice-Chairman*—Ellsworth Shriver, Mead Corp., Chillicothe, Ohio
*Recording Secretary*—Virgil Perry, Harding Jones Co., Middletown, Ohio
*Corresponding Secretary*—Frank C. Duvall, Black-Clawson Co., Middletown, Ohio
*Treasurer*—George B. Gregg, Cincinnati Gas & Electric Co., Cincinnati, Ohio
Malcolm G. Lyon of Champion Paper & Fibre Co. was appointed chairman of the Program Committee

## *Kalamazoo Valley*

The following officers of the Kalamazoo Valley Section were elected at its annual meeting held at Gull Lake Country Club, Kalamazoo, Mich., in June:

*Chairman*—Richard T. Trelfa, Watervliet Paper Co., Watervliet, Mich.
*Vice-Chairman*—Robert T. Elias, Western Michigan College, Kalamazoo, Mich.
*Treasurer*—H. Ray Hall, Allied Paper Mills, Kalamazoo, Mich.

## *Lake Erie*

At its annual meeting of the Lake Erie Section, elected were the following officers for 1955–56:

*Chairman*—Leo Gebo, Thomas Phillips Co., Akron, Ohio
*First Vice-Chairman*—Ted Welles, Moser Bag & Paper Co., Cleveland, Ohio
*Second Vice-Chairman*—C. A. Markee, Ohio Boxboard Co., Rittman, Ohio
*Treasurer*—R. Matthews, Chase Bag Co., Chagrin Falls, Ohio
*Secretary*—Benno Beau, National Container Corp., Jaite, Ohio
*Financial Secretary*—S. B. Gulliford, Gulliford Printing Co., Cleveland, Ohio
*Executive Committeemen*—
R. L. Lewis, Ohio Boxboard Co., Rittman, Ohio
William Schoenberg, Lord & Schoenberg, Cleveland, Ohio
Charles Daggett, Corn Products Sales Co., Cleveland, Ohio
John Preston, Federal Adhesives Co., Cleveland, Ohio
John Richmond, Ace Electrotype Co., Cleveland, Ohio
Marshall Veigel, National Aluminate Corp., Cleveland, Ohio
Jim Krudrna, National Container Corp., Jaite, Ohio

## *Delaware Valley*

The following officers for 1955–56 have been elected by the Delaware Valley Section:

*Chairman*—Philip E. Nethercut, Scott Paper Co., Chester, Pa.
*First Vice-Chairman*—C. R. Calkins, Riegel Paper Corp., Milford, N. J.
*Second Vice-Chairman*—C. F. Ackerman, Union Mills Paper Mfg. Co., New Hope, Pa.
*Treasurer*—D. C. Kane, Hercules Powder Co., Wilimington, Del.
*Secretary*—George K. Boger, Jr., Paper Products Mfg. Co., Swarthmore, Pa.
*Executive Committeemen*—
Frank J. Lovegren, P. H. Glatfelter Co., Spring Grove, Pa.
Emil R. Padavic, Container Corp. of America, Manayunk, Pa.

## *Southeastern*

The Southeastern Section has elected the following officers for 1955–56:

*Chairman*—Charles N. Rodgers, Sonoco Products Co., Hartsville, S. C.
*Vice-Chairman*—William C. Chapman, Union Bag & Paper Corp., Savannah, Ga.
*Treasurer*—Roy H. Homans, Brunswick Pulp & Paper Co., Brunswick, Ga.
*Secretary*—Clarence L. Smith, National Container Corp., Jacksonville, Fla.

## *Pacific*

At its annual meeting held in May at the Empress Hotel, Victoria, B. C., the Pacific Section elected the following officers:

*Chairman*—John M. McEwen, Weyerhaeuser Timber Co., Pulp Div., Everett, Wash.
*Vice-Chairman*—Ben T. Briggs, Rayonier, Inc., Shelton, Wash.
*Secretary-Treasurer*—Robert Smythe, Ray Smythe Co. Portland, Ore.
*Executive Committeemen*—
H. B. Peterson, Hercules Powder Co., Portland, Ore.
Norvall Magnusson, Puget Sound Pulp & Timber Co., Bellingham, Wash.
Kenneth Booth, Crown Zellerbach Corp., Camas, Wash.
S. P. Strayer, St. Regis Paper Co., Tacoma, Wash.

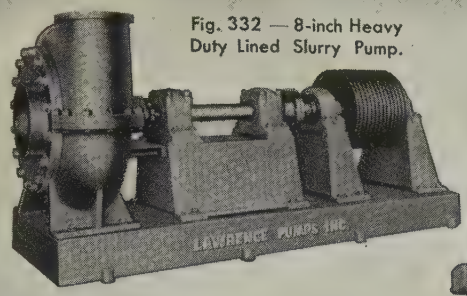


Fig. 332 — 8-inch Heavy Duty Lined Slurry Pump.

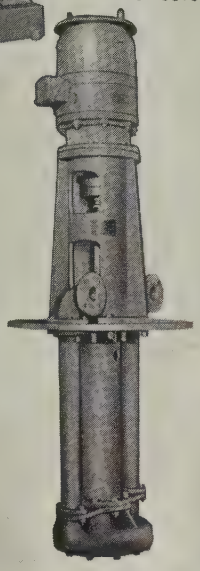


Fig. 244 — 4-inch Vertical Submerged Pump With No Bearings Below the Cover Plate.

Fig. 285 — 5-inch Vertical Top Suction Stock Pump.

Fig. 333 — 24-inch Horizontal Circulating Propeller Pump of Nickel Alloy Construction.

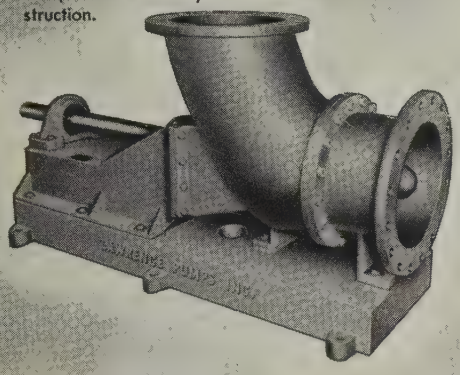
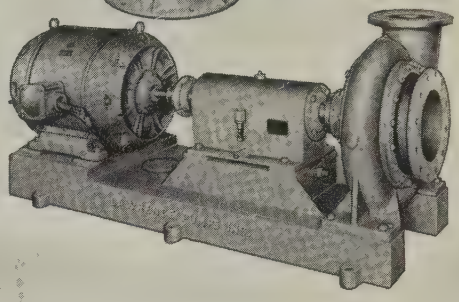


Fig. 337 — Lawrence 10-inch Heavy Duty Stainless Steel Chemical Pump.



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## Lake States

The Lake States Section has elected the following officers for 1955–56:

*Chairman*—S. R. Parsons, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
*Vice-Chairman*—S. J. Baisch, Thilmany Pulp & Paper Co., Kaukauna, Wis.
*Secretary*—D. J. MacLaurin, Gilbert Paper Co., Menasha, Wis.
*Treasurer*—W. J. Bublitz, Kimberly-Clark Corp., Neenah, Wis.
*Executive Committeemen*—
L. A. Moss, Whiting Plover Paper Co., Stevens Point, Wis.
J. R. Salvesen, Marathon Corp., Rothschild, Wis.
J. W. Bard, Marathon Corp., Green Bay, Wis.
R. L. Leaf, Jr., Shawano Paper Mills, Shawano, Wis.
A. Lewenstein, Appleton Coated Paper Co., Appleton, Wis.

## Empire State

At its annual meeting held at Whiteface Inn, Lake Placid, N. Y., on June 11, 1955, the following officers were elected for the 1955–56 term:

*Chairman*—William R. Willets, Titanium Pigment Corp., New York, N. Y.
*First Vice-Chairman*—Gordon K. Storin, Niagara Alkali Co., Niagara Falls, N. Y.
*Second Vice-Chairman*—Grant G. Cole, Finch, Pruyn & Co., Inc., Glens Falls, N. Y.
*Third Vice-Chairman*—J. Wayne Morrow, Newton Falls Paper Co., Newton Falls, N. Y.
*Secretary-Treasurer*—Ralph N. Prince, Fort Orange Paper Co., Castleton, N. Y.
*Executive Committeemen*—officers and
F. G. Sommerville, Armstrong Cork Co., Fulton, N. Y.
D. B. Geffken, Oswego Falls Corp., Fulton, N. Y.
E. H. Johnson, Stevens & Thompson Paper Co., Greenwich, N. Y.
L. R. Ayers, Robert Gair Co., Piermont, N. Y.
R. A. Schwartz, Knowlton Bros., Inc., Watertown, N. Y.
J. J. Forsythe, International Paper Co., Niagara Falls, N. Y.
H. A. Spencer, Knowlton Bros., Inc., Watertown, N. Y.

## Empire State (Central District)

*Chairman*—D. B. Geffken, Oswego Falls Corp., Fulton, N. Y.
*Chairman-Elect*—W. A. Holl, Victoria Paper Mills, Fulton, N. Y.
*Secretary*—Mrs. Barbara Wortley, Solvay Process Div., Syracuse, N. Y.
*Treasurer*—S. Earll Church, College of Forestry, State University of New York, Syracuse, N. Y.

## Empire State (Eastern District)

*Chairman*—E. H. Johnson, Stevens & Thompson Paper Co., Greenwich, N. Y.
*Chairman-Elect*—Vincent Long, American Wood Board Co., Greenwich, N. Y.
*Secretary*—Thomas McGreen, International Paper Co., Glens Falls, N. Y.
*Treasurer*—Clyde Davis, Jr., Finch, Pruyn & Co., Inc., Glens Falls, N. Y.

## Empire State (Metropolitan District)

*Chairman*—L. R. Ayers, Robert Gair Co., Piermont, N. Y
*Chairman-Elect*—John H. Doherty, Union Bag & Paper Corp., New York, N. Y.
*Secretary-Treasurer*—W. A. Beman, Socony-Mobil Oil Co., New York, N. Y.

## Empire State (Northern District)

*Chairman*—R. A. Schwartz, Knowlton Bros., Inc., Watertown, N. Y.
*Chairman-Elect*—P. R. Anderson, St. Regis Paper Co., Deferiet, N. Y.
*Secretary*—Miss Elizabeth Case, Stebbins Engineering & Mfg. Co., Watertown, N. Y.
*Treasurer*—J. C. Parsell, J. P. Lewis Co., Beaver Falls, N. Y.

## Empire State (Western District)

*Chairman*—James J. Forsythe, International Paper Co., Niagara Falls, N. Y.
*Chairman-Elect*—R. H. Zinsmeister, Kimberly-Clark Corp., Niagara Falls, N. Y.
*Secretary*—H. E. Lindeberg, Robert Gair Co., North Tonawanda, N. Y.
*Treasurer*—E. F. Andrews, International Paper Co., Niagara Falls, N. Y.

## Second Mechanical Pulping Conference

The Second International Mechanical Pulping Conference, jointly sponsored by TAPPI and the Canadian Pulp and Paper Association Technical Section, will be held at Poland Spring House, Poland Spring, Me., Sept. 19–21, 1955.

Reservations for the conference should be made directly with Daniel A. Barry, resident manager, Poland Spring House, Poland Spring, Me.

The program for the conference is shown below.

### Program

*Monday, Sept. 19, 1955*

8:00 a.m. Registration

9:45 a.m. Opening Remarks, T. F. LaHaise, Imperial Paper & Color Corp., Plattsburg, N. Y., *General Chairman.*

10:00 a.m. General Session, W. Gallay, Director of Research the E. B. Eddy Co., Hull, Que., *Chairman.*
1. "The Potential of Groundwood," by W. Gallay.
2. "The Grinding Process—A Basic Approach," by D. Atack, Pulp and Paper Research Institute of Canada, Hull, Que.
3. "Groundwood Production Related to Fiber Technology," by K. Klemm, Anglo-Newfoundland Development Co., Grand Falls, Newfoundland.

2:00 p.m. Wood Utilization Session, F. W. O'Neil, New York State University, College of Forestry, Syracuse, N. Y., *Chairman.*
1. "Conservation and Utilization of Wood for Mechanical Pulping," by R. W. Marquis, Northeastern Experiment Station, U. S. Dept. of Agriculture, Upper Darby, Pa.
2. "The Grinding of Pretreated Hardwoods," by A. Hyttinen and E. R. Schafer, Forest Products Laboratory, Madison, Wis.
3. "Commercial Production of Chemigroundwood for Newsprint," by J. H. Heuer, Great Northern Paper Co., East Millinocket, Me.

7:00 p.m. Banquet
*Speaker:* James L. Ritchie, Executive Director, United States Pulp Producers Association, New York, N. Y.
*Subject:* "The Groundwood Economy."

*Tuesday, Sept. 20, 1955*

9:30 a.m. General Session, K. Pingrey, Diamond Match Co., Ogdensburg, N. Y., *Chairman.*
1. "Pitless Grinding and Norwegian Groundwood Practices" by C. Anker, Risor Tremassefabrikker, Risor, Norway.
2. "The Norton-Great Northern Research Stone," the Norton Co., Worcester, Mass.

10:30 a.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Printing and Specialty Papers.

2:00 p.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Board and Container Grades.

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3:00 p.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Tissue and Toweling.

7:30 p.m. Refining Session—T. G. Rust, Quebec North Shore Paper Co., Baie Comeau, Quebec, *Chairman.*

1. "Low Consistency Refining of Groundwood Rejects at Spruce Falls Power and Paper Co." by R. H. Stafford and E. Gardiner, Spruce Falls Power & Paper Co., Kapuskasing, Ont.
2. "The Reisten Refiner," by E. F. Walsh, Anglo-Canadian Pulp and Paper Mills, Quebec, Que.

*Wednesday, Sept. 21, 1955*

9:30 a.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Newsprint.

George E. Shipman, Donnacona Paper Co., Donnacona, Quebec, *Moderator.*

*South*—C. C. Porter, Southland Paper Mills, Lufkin, Tex.

*Northeast*—W. F. Daniell, Great Northern Paper Co., Millinocket, Me.

*Canada*—H. A. Paterson, Mersey Paper Co., Liverpool, Nova Scotia.

*West*—N. F. Robertson, West Tacoma Newsprint Co., Steilacoom, Wash.

2:00 p.m. Symposium—Cleaning and Bleaching, J. L. Parsons, Consulting Engineer, Waterville, Me., *Chairman.*

1. "Hydrosulphite Bleaching of Groundwood," by D. B. Sparrow, Scott Paper Co., Chester, Pa.
2. "Multistage Bleaching of Groundwood Using the Peroxide and Hydrosulphite Processes," by C. A. Richardson, Blandin Paper Co., Grand Rapids, Minn.
3. "Peroxide Bleaching of Groundwood," by Finch, Pruyn Co., Glens Falls, N. Y.
4. "Tabular Summary of Bleaching Methods for Groundwood," by A. A. Yankowki, Kimberly-Clark Corp., Neenah, Wis.

In addition, several papers will be presented on the cleaning of groundwood by pressure-drop methods (Dirtec, Vortrap, Bauer cleaners).

## *Sixth Testing Conference*

From woodlot to the end user, the production speeds of all phases of papermaking have increased greatly since the last war. This "speed-up" includes most converting, printing, and consuming operations as well as the production of pulp, paper, and paperboard, *per se.* This increase in speed has created many new, and emphasized many old problems.

The Testing Division of TAPPI is establishing a new standing committee to develop and evaluate means needed to cope with these new conditions. Such tests must be simply and quickly made, must repeat their findings with reasonable fidelity, and must supply the machine operator with information that will enable him to maintain the quality of his production within allowable standards. They should supply *correct* information, *quickly enough*, so that decisions can be made in time to *prevent* the production of inferior or unsuitable material. These tests will, of necessity, be in addition to and quite different from the TAPPI Standards ("referee" tests), and Suggested Methods which have been the responsibility of the Testing Division standing committees.

Those willing to cooperate in the development and evaluation of testing methods, procedures, and instruments that can be used as production controls, are urged to attend the Sixth TAPPI Testing Conference, Sheraton-Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955.

Many converters, printers, and other users of paper and paperboard products, and of items made therefrom, do not realize what the Testing Division of TAPPI is doing in their behalf nor what additional work of that nature can be done. The Testing Division of TAPPI has the responsibility of developing and of evaluating tests for any paper product, any product made from paper that is requested by any group willing to cooperate in the undertaking. This would include tests for raw materials, components, "in work" tests, and tests upon the finished products.

For example, standing committees have been formed to develop and evaluate testing procedures for

Corrugated (components—board—boxes)
Shipping Sacks (components—bags—filled bags)
Container (boxboards—cartons—printing characteristics)
Packaging Materials (physical properties—special requirements)

Other, probably better known, Testing Division standing committees, can be grouped as follows:

Testing Methods
  Microscopy—Optical Properties—Chemical Methods
Testing of Raw Materials
  Fibrous Materials—Nonfibrous Materials—Wax
Testing of Materials
  Pulp—Paper

All interested in partaking of scheduled committee work or of establishing additional committee programs should attend the Sixth TAPPI Testing Conference at the Sheraton-

***Testing Conference members will visit the Strathmore Paper Co., West Springfield, Mass.***

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***Technifax Corp., Holyoke, Mass., will welcome visitors from the Sixth Testing Conference***

Kimball Hotel, Springfield, Mass., Sept. 28–30, 1955. There you can contact the chairman of the committee concerned with your project or else contact the chairman of the Testing Division of TAPPI, James P. Casey.

*Summary of the Sixth TAPPI Testing Conference*

*Date*—Sept. 28–30, 1955.
*Place*—Springfield, Mass., Sheraton-Kimball Hotel.
*Events*—

September 28—Committee Meetings
Reports on original technical work by committee members and on committee activities, discussions, future plans.
September 29—Presentation of technical papers (titles and speakers to be announced next month).
September 30—Mill visits to Strathmore Paper Co., and Technifax Corp.
September 28–30—Exhibition of Testing Instruments.

WM. SCHOENBERG, *Chairman*
*Publicity Committee*
*Sixth TAPPI Testing Conference*

## *Sixth Coating Conference*

The Sixth Coating Conference of the Technical Association of the Pulp and Paper Industry was held at the Hotel Statler, Cleveland, Ohio, on May 23–25, 1955. A total of 454 delegates attended the meeting, which thus closely approached the record-breaking attendance of 455 of last year's Poland Spring conference. This year for the first time the conference was jointly sponsored by the Coating Committee under the chairmanship of R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich., and the Graphic Arts Committee under the chairmanship of C. A. Morton, West Virginia Pulp and Paper Co., Chicago, Ill.

The general chairman of the conference committee was John D. Davis, Mead Corp., Chillicothe, Ohio. Mr. Davis was assisted by the following committee members: J. E. Wilber, program, St. Regis Paper Co., Deferiet, N. Y.; L. H. Silvernail, publicity, Dow Chemical Co., Midland, Mich.; R. N. Thompson, exhibits, Calgon, Inc., Pittsburgh, Pa.; Wm. Schoenberg, local arrangements, Lord & Schoenberg, Cleveland, Ohio. The local arrangements committee, assisting Mr. Schoenberg, consisted of the following members: J. F. Richmond, vice-chairman, The Ace Electrotype Co., Cleveland; D. H. Bechtold, hotel liaison, Monsanto Chemical Co., Cleveland; R. C. Bascom, ladies' affairs, B. F. Goodrich Chemical Co., Cleveland; S. B. Gulliford, registration, Gulliford Printing Co., Cleveland; C. M. Daggett, reception, Corn Products Sales Co., Cleveland; and T. M. Wells, mill visits, Moser Bag & Paper Co., Cleveland. Assisting Mr. Wilber on the program committee were: J. W. Swanson, Institute of Paper Chemistry, Appleton, Wis.; W. R. Willets, Titanium Pigment Corp., New York, N. Y.; C. G. Albert, Minerals and Chemicals Corp. of America, McIntyre, Ga.; and R. W. Hagemeyer, Wyandotte Chemical Corp., Wyandotte, Mich.

The technical program, which was centered around the theme "Pigments in Paper Coating," consisted of four technical sessions and a discussion panel on the theme subject. The papers presented during the sessions are outlined briefly in the account that follows and will be published in full in future issues of *Tappi*.

Features of the conference also included the official luncheon on Tuesday, May 24, exhibits by manufacturers of pigment mixing equipment, and visits to plants and mills in the area.

### *Technical Sessions*

The conference was opened by General Chairman John D. Davis, Mead Corp., Chillicothe, Ohio, and R. T. Trelfa, Watervliet Paper Co., Watervliet, Mich., chairman of the Coating Committee. Mr. Davis introduced J. E. Wilber, St. Regis Paper Co., Deferiet, N. Y., chairman of the opening session.

Mr. Wilber introduced Albert W. Wilson, *Pulp and Paper*, Chicago, Ill., who spoke on "The Future Outlook for Coated Papers from the Point of View of Advertisers, Publishers, Printers and Other Users."

Mr. Wilson discussed the new trend for greater eye appeal in packaging, publishing, and advertising to provide more incentive for impulse buying and the impact of this trend upon the coating industry. In view of what is happening today in the publishing world, the advertising world, and the supermarket, the speaker felt that the day is coming when most paper and paperboard will be coated by some means or other. Even newsprint may be coated in order to compete with other advertising media, but new tariff laws would be necessary to render this possible.

In order to point out possible directions in which coated papers may be improved, Mr. Wilson presented a number of suggestions made by printers in the Chicago area as to what improvements they would like to see in the paper they are using.

The second paper of the opening session was entitled "Method for Deaerating Coating Color" and was presented by John Gunning, Provincial Paper Co., Georgetown, Ont., Canada. Mr. Gunning discussed the results of entrained air in coating, such as increased apparent viscosity, power leveling, pits and pin holes in the resulting coat. Since the Deculator, designed by Rotareaed of Canada, effectively removes air from paper stock, it was conceived that a similar apparatus might be practical for coating colors. An agreement was reached whereby Rotareaed would design and construct an apparatus and Provincial Paper Co. would evaluate it.

Mr. Gunning described the construction of a stainless steel vessel at Georgetown with the necessary auxiliary equipment, such as vacuum pumps, color pumps and controls. Preliminary evaluations were carried out by cycling the coating in a closed system to show that there was no breakdown or harmful effects. It was established that air could be efficiently removed. The data obtained were used to redesign the equipment which was then installed on an air-knife coater. The results on the coated paper and machine operation were discussed.

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The final paper of the Monday morning session was titled "An Electrostatic Process for Applying Dry Coatings on Paper" and was presented by Robert Reif, Battelle Memorial Institute, Columbus, Ohio. Mr. Reif described the electrostatic process developed at Battelle for coating paper with dry coating materials in powder form. The coating material, suspended as a dust cloud in air, is charged electrically and deposited on the web with strong electrostatic fields. Mr. Reif described the general design and operation of the coating unit, the nature and preparation of the coating materials, and the types of coating made by the process. The author stated that the process may be used to apply many different resins and pigments, and to provide a wide variety of properties in coatings.

The Monday afternoon session was under the chairmanship of C. G. Albert, Minerals and Chemicals Corp. of America, Edgar Bros. Division, Metuchen, N. J.

Gerald Haywood, West Virginia Pulp & Paper Co., Luke, Md., was the first speaker of the session. Mr. Haywood described the manufacture of clay, chalk, and titanium dioxide for use in paper coating, and the testing procedures which may be used to characterize these pigments. The author also discussed pigment characteristics that contribute to the formation of a good coated surface, and the ways in which pigments may be modified to make them more suitable for paper coating. Concluding with a discussion of synthetic pigments, Mr. Haywood described means of reducing adhesive demand, for example, by subjecting the wet pigment to pressure.

The second paper of the session "Mineral Species in Coating Clays and Their Relationship to Flow Properties at High Solids Content," by J. N. Swanson and G. Hemstock, The Institute of Paper Chemistry, Appleton, Wis., was presented by Mr. Swanson. Mr. Swanson discussed the x-ray defraction methods that have been used at The Institute of Paper Chemistry for the identification of the mineral species in fractionated samples of crude and commercial coating clays. Although kaolinite is the predominant mineral species in all coating clays, the author stated that small amounts of bentonite were found in the finer particle size fractions of some clays and small amounts of quartz were found in the coarser fractions of others. Mica and/or illite were identified in all fractions of one coating clay. Mr. Swanson presented evidence that all these minerals can affect the flow properties of clays at a high solids content but amounts of ventinite or illite in the coating clays which cannot be detected by x-ray defraction will greatly increase the apparent viscosity. The authors have concluded from an examination of the relative importance of particle shape, size, and size distribution, dispersing agent requirement, and the mineral species that the variable viscosity of coating clays is due primarily to the small variable amounts of ventinite-type minerals which they contain.

The following paper, also by Messrs. Swanson and Hemstock, was on "Clay Deflocculation and Its Effect on the Flow Properties of Clay Slips." The author described an experimental study of dispersing agent action as it affects the flow properties of coating clays. Evidence was presented showing that the pH and conic strengths of the intermicellar solutions and the structure of the dispersing agent anion are critical factors in determining the effectiveness of a deflocculent for clays. The author discussed these observations in the light of modern theories of the stability of lyophobic colloids and present knowledge of the structure of laolinite

The final paper of the Monday afternoon session, "Some Aspects of Dispersion" by W. R. Willets and L. E. Georgevits, Technical Service Laboratories, Titanium Pigments Corp., New York, N. Y., was presented by Mr. Willets. Mr. Georgevits is at present with the Borden Co., Bainbridge, N. J. Fundamental concepts of dispersion with particular reference to titanium pigments. A powdered pigment consists of aggregations of smaller particles and mechanical work is required to break them down into smaller units. Once so dispersed such units are free to move about and form different associations than existed in the original aggregates. They may be kept in the dispersed condition or flocculated by the addition of materials which will alter the charges on them. A primary particle is usually considered as one which can only be reduced in size by fracture, since it is questionable whether usual milling procedures reduce a pigment to this extent. The actual particle dealt with ("ultimate working unit") is usually a group of primary particles that retains its structure throughout the dispersion process. Such aggregates may be of dense or open structure. An agglomerate is usually considered as a loosely bound aggregate formed by the dry handling of the pigment containing some absorbed air. A flocculate is usually considered as a loosely bound aggregate formed by the dry handling of the pigment containing some absorbed air. A flocculate is usually considered as a loose cluster of primary working units which were in the dispersed form prior to flocculation.

The presence of oversize material in a coating color regardless of whether it consists of hard or loosely bound aggregates, agglomerates, or flocculates is detrimental, causing poor finish, uneven printing, picking, and dusting. Furthermore, the maximum efficiency of a pigment is developed at a definite particle size and oversize particles detract from the development of maximum hiding power.

The dispersion of pigments for use in coating color consists of reducing the size of the aggregates by mechanical means in the presence of a deflocculating surface-active material known as a dispersant. The effect of various dispersants on the preparation of water slurries of titanium pigments and other minerals varies and certain dispersants are incompatible with each other. Water hardness and pH also have a marked effect. The viscosity and total solids of a slurry have a definite effect on the efficacy of milling.

The flocculating effect of casein or isolated protein when added quickly to well-dispersed water slurries of titanium dioxide or clay may also be a cause of aggregates in the final coating color. Dried coating around tank edges, on agitators, elsewhere may also drop back into the color and cause "sandy coatings" since they do not completely redisperse.

The importance of proper dispersion cannot be overemphasized as demonstrated by examples from experimental and commercial practice.

Following presentation of the papers, a film entitled "The Ninth Element," was shown by the Titanium Pigment Corp., New York, N. Y., depicting the mining of titanium ores in various parts of the world, and the processing of titanium pigments.

*May 24 Sessions*

On Tuesday, May 24, the morning session was under the Chairmanship of W. R. Willets, Titanium Pigment Corp., New York, N. Y.

Mr. Willets introduced R. W. Hagemeyer, Wyandotte Chemical Corp., Wyandotte, Mich., who presented a paper entitled "Calcium Carbonate Pigments."

Mr. Hagemeyer discussed sources and methods of manufacture of precipitated calcium carbonate, and presented photomicrographs of representive physical forms. After summarizing the relationships between particle size and coating properties for a specific product, the author described the performance of a 0.2-micron precipitated calcium carbonate in various adhesive systems both alone and in combination with other pigments. In concluding, Mr. Hagemeyer outlined some of the future possibilities for calcium carbonate pigments.

Clyde W. Leaf presented the next paper entitled "Aqueous Dispersions of Calcium Carbonate—Evaluation of Methods and Dispersants," by Mr. Leaf and L. W. Liggett, Wyandotte Chemical Corp., Wyandotte, Mich.

# PAPER

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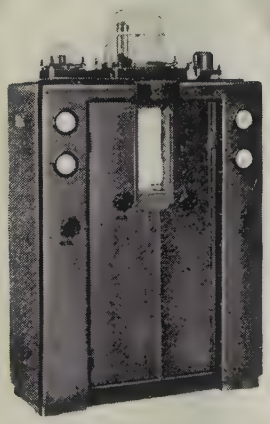

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Mr. Leaf described an investigation of some of the factors affecting the preparation of high solids, low viscosity, aqueous slurries of precipitated calcium carbonate.

Using a crossarm mixer operating at moderate speeds, it has been found possible to prepare aqueous slurries of precipitated calcium carbonate (Wyandotte's Purecal M) containing up to 70% solids by weight. The effect of a number of dispersants, both inorganic and organic, has been investigated. Generally, Mr. Leaf reported, the inorganic polyphosphates were found most effective.

These high solids slurries have viscosities of about 10,000 cp. and are slightly dilatant. Dilution to lower solids concentrations gives thixotropic slurries with unexpectedly low viscosities—very much lower than would be found if the slurries were made up directly to the same solids concentration.

Precipitated calcium carbonates ordinarily exist as aggregates of small crystalline particles. Stirring the very high solids dilatant slurries causes the large aggregates to break down into the small ultimate particles. Slurries of these smaller particles are much less viscous than slurries of the larger aggregated masses at a given solids concentration.

B. W. Rowland, Georgia Kaolin Co., Dry Branch, Ga., presented the third paper of the Tuesday morning session entitled "Progress Notes on Machine Coating." Mr. Rowland presented a brief review of certain aspects of the machine coating problem. The author emphasized the importance of "water mechanism" originally defined in terms of the "blotter test" and, more recently, "water release." The water release was originally related to clay but has more recently been found to relate not only to clay itself, but to the amount of dispersing agent, as does the high shear viscosity behavior. Mr. Rowland suggested that the effect of starch on coating color rheology and its water release become secondary to that of the clay under high shear conditions, and described the problems and procedures used by a Georgia kaolin producer to provide paper mills with suitable and uniform coating clays.

"Varnish Resistance of Various Clays and Pigments" was the title of the fourth paper of the Tuesday morning session, presented by John C. Rice, Lowe Paper Co., Ridgefield, N. J. Mr. Rice described a laboratory study of the qualities of varnished coatings made with a variety of clays and white pigments. The author described the relationships between the per cent adhesive, varnished glass, and varnished brightness with these coating materials, and presented an evaluation of ink absorbency.

The fifth paper of the session was entitled "Some Fundamental Properties of Commercial Talcs and Their Possible Application to Papermaking," by R. S. Lamar and M. F. Warner, Sierra Talc and Clay Co., South Pasadena, Calif. The authors stated that the word "talc," as applied to commercially available products, included a great variety of related minerals and mixtures of such minerals. These products show variations in both chemical and physical properties from one grade to another and from one supplier to another. The mineral talc is a hydrous magnesium silicate of definite composition and physical properties. It has a Mohs hardness of 1 as compared with 2 for the pure kaolins or papermaking clays. Associated mineral impurities, contained in many commercial talcs, show Mohs hardness of from 4 to 7. These talcs are unsatisfactory for papermaking because of excessive abrasiveness. The highly tremolitic talcs mined in the Eastern United States are good examples of these abrasive materials. Commercial talcs consisting almost entirely of pure talc mineral are produced in California and Nevada. These materials are soft, nonabrasive and are adaptable to a variety of papermaking applications. These products are available at G.E. brightness ratings of 92 to 96 and particle size distributions showing 100% finer than 9 microns and average particle size of 0.35 micron, to take advantage of maximum light scattering.

M. J. Landberge, General Dyestuff Co., Div., General Aniline and Film Corp., New York, N. Y., presented the final paper of the Tuesday morning session, entitled "Tinting and Coloring of Water Vehicle Coatings." Mr. Landberge presented a brief discussion of the various classes of dyestuffs and types of colored pigments used for coloring coatings, methods of application and fastness properties.

The first item of the Tuesday afternoon session was a paper entitled "A New Replica Technique for Making Electron Micrographs of Coated Paper Surfaces" by J. J. Comer and H. W. Stetson, Pennsylvania State University, State College, Pa., and S. C. Lyons, Georgia Kaolin Co., Dry Branch, Ga.

Prior electron microscope studies in this field have been limited to examinations of the coating materials in a dispersed state. Kaolinite finer than 2 microns was shown to consist mostly of flat, hexagonal plates, whereas particles greater than 2 microns contain many "books" or large aggregations of plates. Using such data, Woodward and Lyons postulated that the gloss developed by the finer clay sizes was due to their preferred orientation parallel to the surface of the coating, whereas the coarser stacked particles deposit so that the edges of their component crystal plates are at angles to the coating surface.

The development of the preshadowed carbon replica method has afforded dramatic proof of the correctness of the hypothesis of Woodward and Lyons. Previous replica methods failed because of the porous nature of the sample or because the paper coating material could not be removed from the replica. Since both platinum shadowing metal and the supporting carbon film are vaporized onto the surface and involve no liquid phase, porosity is not a great problem. The clay or other surface-coating material is readily dissolved in hydrofluoric acid while the platinum and carbon are unaffected. This technique has a very high resolving power, showing detail on the surface of individual kaolinite flakes.

Papers coated with titanium dioxide, calcium carbonate, and zinc oxide were also examined by this technique and each is shown to have a characteristic structure.

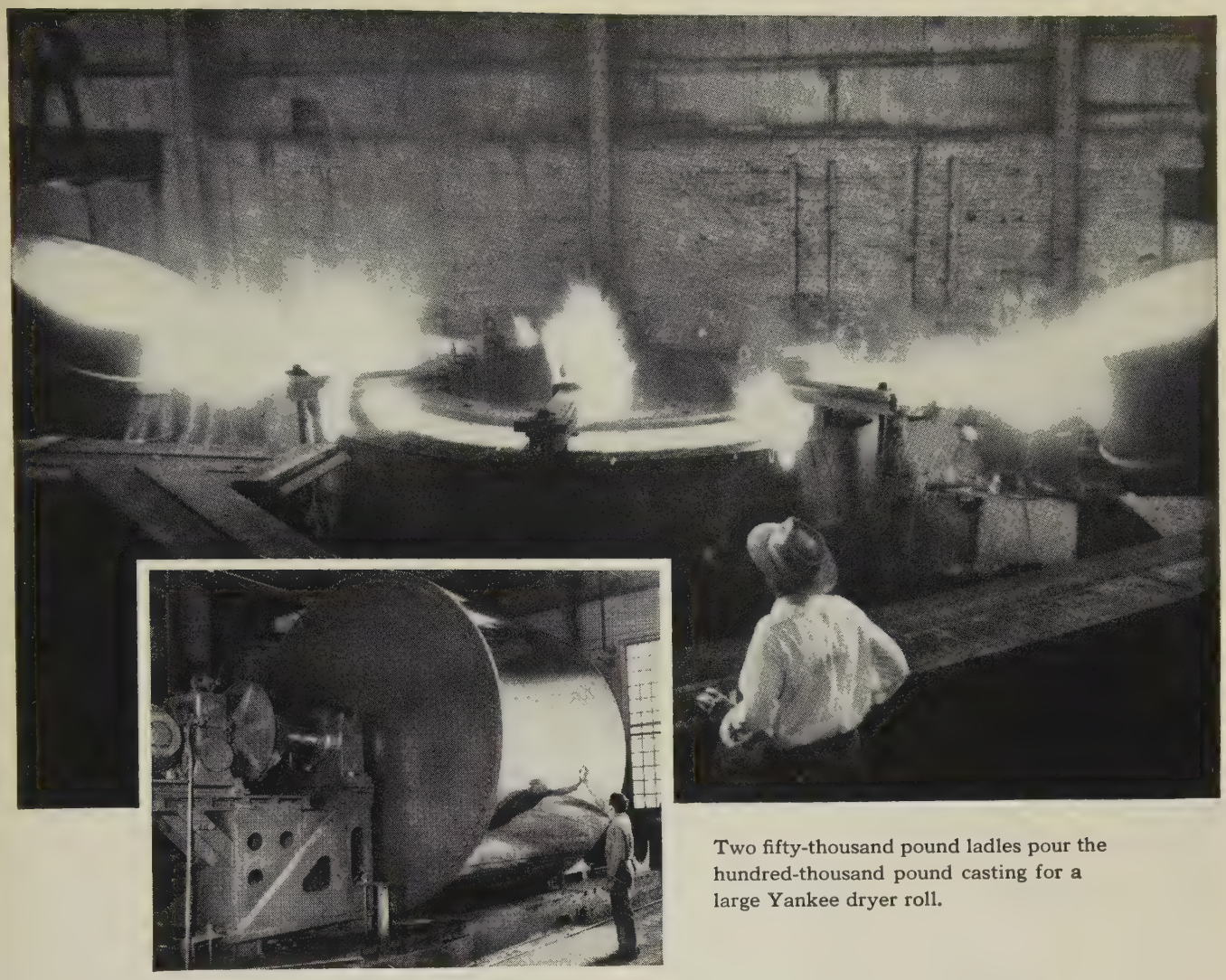
Following Mr. Comer's presentation, a panel discussion on pigments was held under John W. Swanson, moderator, The Institute of Paper Chemistry, Appleton, Wis. Members of the panel were the authors of the papers which had been presented, including C. W. Leaf, R. W. Hagemeyer, M. F. Warner, S. C. Lyons, J. J. Comer, W. R. Willets, G. Hemstock, J. C. Rice, and M. J. Landberge. A full report of the discussions will be published in a forthcoming issue of *Tappi*.

*May 25 Sessions*

On Wednesday, May 25, a Graphic Arts session was held, sponsored by the TAPPI Graphic Arts Committee, under the chairmanship of C. A. Morton, West Virginia Pulp and Paper Co., Chicago, Ill.

"Coated Paper Requirements for High-Speed Letterpress Printing" was the title of the first paper, presented by A. Glassman, R. R. Donnelly & Sons Co., Chicago, Ill. Mr. Glassman discussed the evaluation of coated paper surfaces in the light of requirements for high speed, high quality production of magazines and catalogs, and described a method for measuring the relative tolerance of coated papers to printing impression. The author also described a "tensile at fold" test method which correlates with important aspects of bindery performance.

The second paper of the Graphic Arts session entitled "Coated Paper Properties and Their Relation to Printability and Print Quality in Lithography" was presented by R. F. Reed, Lithographic Technical Foundation, Chicago, Ill. Mr. Reed defined printability as the combined properties and condition of paper that affect its press performance. The properties involved are plasticity, curling tendency, pick strength, moisture resistance, moisture absorbency, surface



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ink absorbency, and alkalinity. Conditions affecting press performance are flatness and freedom from dust, fibers, and foreign matter. The author defined print quality as the general appeal or attractiveness of the printed reproduction to the viewer. The attractiveness is largely subjective and involves realism in tone and color, contrast, smoothness or graininess of tones and solids, sharpness, and clarity of detail. These effects are to a certain extent interrelated and interdependent. The author felt that while they are subjective, the physical and optical properties that produce them should be capable of being measured once we have developed methods and gained sufficient experience.

J. Homer Winkler, Battelle Memorial Institute, Columbus, Ohio, presented the following paper entitled "An Approach to the Printability Evaluation Problem." Mr. Winkler discussed the significance and extent of the printability problem and outlined the diversity of interests and concepts pertaining to its evaluation. Basing his discussion on Schaffert's definition of printability, the author described the major factors affecting printability, and indicated the relations of the effects of paper, ink, and ink transference. Mr. Winkler suggested that the makers of paper, ink, and equipment and the printers should define the information they need and and that the relationships of these interests should be established as a first step in a program of research on printability. Following this a careful survey and analysis of work that has been done in this field should be made to correlate techniques and data. Mr. Winkler suggested that such an approach should then make it practicable to outline an effective program of research concerning the effects of the three principal factors upon printability.

The fourth paper of the Graphic Arts Session, "Effect of Smoothness and Compressibility on Printing Quality of Coated Paper" was presented by W. W. Roehr, Kimberly-Clark Corp., Neenah, Wis. Mr. Roehr discussed the characteristics of coated book paper which influence its printability, such as surface levelness and compressibility, and described several new techniques that have been developed for evaluating these properties. The Brush Surface Analyzer determines smoothness by tracing the surface of a test strip with a small diamond stylus, the motion of which is magnified and recorded. An electronic device counts the number of surface depressions as well as their average width. Depressions shallower than any predetermined depth are automatically excluded. For compressibility measurements an apparatus has been constructed which will measure the thickness of a piece of paper with an accuracy of about 0.000025 in. at compressive forces up to 1000 p.s.i. The author described several applications of these techniques to studies of the relation of surface smoothness and compressibility to printing qualities. On coated book papers a good correlation was found between letterpress halftone printability and Brush smoothness values. Compressibility appears to play a minor role on heavily coated papers, but becomes increasingly important at lower coating weights.

Following Mr. Roehr's paper, a film entitled "Ink Film Splitting" was presented by O. C. Holland, Interchemical Corp., New York, N. Y. This was a motion picture study showing the way in which an ink film separates on laboratory pick testing equipment as well as commercial presses.

### *Official Luncheon*

The official luncheon of the Sixth Coating Conference was held on Tuesday, May 24. Previous coating conferences have featured addresses by outstanding leaders in the paper industry, and this year's address was given by George K. Ferguson, president and general manager, Watervliet Paper Co., Watervliet, Mich.

The master of ceremonies was John D. Davis, general chairman of the conference. Mr. Davis introduced the individuals seated at the head table and others who had contributed to the planning and organization of the conference. R. T. Trelfa, chairman of the Coating Committee, and C. A. Morton, chairman of the Graphic Arts Committee, spoke briefly on behalf of their respective committees, and K. O. Elderkin, president of TAPPI, addressed the group on behalf of the national organization.

Mr. Davis introduced Mr. Ferguson who spoke on "Coating Frontiers." Commenting on the tremendous progress of the past 50 years in all fields of knowledge and human endeavor, Mr. Ferguson pointed out that probably not more than 15% of paper was coated, while today 59% of all book paper is coated, and it appears probable that in the not too distant future as much as 90% of the printing paper in this country will have a coating of some type.

Progress in coating, Mr. Ferguson stated, will depend on three principal factors: mechanical improvements, new developments in pigments and adhesives, and economics. Improved finishing methods and automatic inspection will also help to reduce costs.

Mr. Ferguson warned against becoming so involved in our own work that we are not alert to the present-day threats to the realization of future freedom, peace, and material prosperity. The tendency to deficit spending, inflation, and extension of government ownership jeopardizes the possible attainment of these aims.

### *Exhibits*

There were three exhibitors: the Cleveland Mixer Co., Bedford, Ohio; The J. H. Day Co., Inc., Cincinnati, Ohio; and The Patterson Foundry & Machine Co., East Liverpool, Ohio. Various devices for mixing coating colors were shown.

### *Mill Visits*

On Wednesday afternoon, May 25, delegates were invited to visit the Ohio Boxboard Co., Rittman, Ohio; The Glidden Co., Cleveland, Ohio; or the Sherwin-Williams Co., Cleveland, Ohio.

About 80 delegates visited Ohio Boxboard, which is one of the largest integrated boxboard plants in the country. The mill division has four cylinder machines with a combined capacity of 600 tons of paperboard daily. Of particular interest to coating men were the three machines equipped with Champion coaters for producing on-machine coated boxboard. The folding carton plant is the country's largest under one roof, and is equipped with 16 presses in addition to cutting and gluing equipment. The container department has two high-speed corrugaters and a Hudson-Sharpe printer-tinter for coating liner board, as well as many types of converting equipment.

The printing division of the Sherwin-Williams Co. was toured by over 30 delegates who had an opportunity to see the facilities used by S-W to produce labels, stationery supplies, advertising materials, and various printing material for the company's 775 branches and affiliates.

Approximately 30 delegates visited the plant of the Glidden Co., where they observed the mixing and manufacturing of paint, enamel, and other industrial finishes, and toured the company's research and development laboratory.

"En Route" visits were also arranged, so that delegates who wished to do so could tour the following mills: the Hammermill Paper Co., Erie, Pa.; the Shellmar-Bettner Division, Continental Can Co., Mount Vernon, Ohio; the Consolidated Paper Co., Monroe, Mich.

### *1956 Coating Conference*

The Seventh Coating Conference will be held at the Benjamin Franklin Hotel, Philadelphia, Pa., May 7 to 9, 1956. Joseph T. Loomer, Robert Gair Co., Uncasville, Conn., is general chairman of the conference and Chester G. Landes, American Cyanamid Co., Stamford Conn., is program chairman. The theme of the conference will be "Adhesives for Paper Coating." Anyone interested in supplying a paper for the conference should write to Mr. Landes.

# PERSONAL MENTION

## *Items About New and Old Tappimen*

### *New TAPPI Members*

*Selden K. Adkins,* Director, Technical Service, National Aluminate Corp., Chicago, Ill. Attended the University of Omaha.

*Douglas W. Ambridge.* President and General Manager, Abitibi Power & Paper Co. Ltd., Toronto, Ont., Canada, a 1923 graduate of McGill University.

*Nicholas Bachinski,* Application Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio, a 1947 graduate of the University of Manitoba, and a 1953 graduate of Harvard University.

*G. Barette,* Manager, Institut Belge de l'Emballage, Brussells, Belgium.

*Henry B. Barrow,* Application Engineer, General Electric Co., Atlanta, Ga., a 1923 graduate of Virginia Military Institute.

*Stanley J. Batruk, Jr.,* Sales Engineer, The New Jersey Zinc Co., New York, N. Y., a 1941 graduate of St. Peter's College.

*Howard Baumgarten,* Economist, Parsons & Whittemore, Inc., New York, N. Y., a 1948 graduate of the University of Michigan.

*Erwin Bettschen,* Student, Oscar von Miller Polytechnikum, Munich, Germany.

*Gino P. Biasi,* Student, State University of New York, College of Forestry, Syracuse, N. Y.

*Munro L. Boinest, Jr.,* Paper Mill Superintendent, Halifax Paper Co., Inc., Roanoke Rapids, N. C., a 1941 graduate of Virginia Polytechnic Institute.

*George A. Bowman,* Sales Engineer, Dravo Corp., Pittsburgh, Pa., a 1938 graduate of the University of Maryland.

*Gerard Chapman,* Chemist in Charge of Quality Control and Testing, Columbia Box Board Mills, Inc., Walloomsac Div., N. Hoosick, N. Y., a 1937 graduate of Massachusetts Institute of Technology.

*Punya Brata Chaudhuri,* Chemical Engineer, Svenska Cellulosa A/B, Sundsvall, Sweden, a 1953 graduate of College of Engineering and Technology, Calcutta, India.

*Allen L. Christian,* Paper Manufacturing Assistant, Kimberly-Clark Corp., Neenah, Wis., a 1951 graduate of Carroll College.

*Harlan C. Craig,* Industrial Engineer, The Foxboro Co., Foxboro, Mass., a 1938 graduate of the University of Illinois.

*Louis F. Cross, Jr.,* Assistant Sales Manager, The Black-Clawson Co., Pandia Div., New York, N. Y., a 1940 graduate of Stevens Institute of Technology.

*Thomas L. Draper,* District Manager, Schenectady Resin Co. Div., Schenectady Varnish Co., Schenectady, N. Y., a 1936 graduate of Washington University, and a 1944 graduate of Harvard University.

*Peter S. Dunnett,* Technical Manager, Samuel Jones & Co. Ltd., London, England, a 1947 graduate of London University.

*Thomas W. Edwards, Jr.,* Staff Industrial Engineer, The Champion Paper & Fibre Co., Pasadena, Texas, a 1948 graduate of Georgia School of Technology.

*Antonio B. Espasa,* Executive Vice-President, Fosforera Venezulana S.A., Caracas, Venezuela, a graduate of the University of Central Madrid with a Ph.D. degree.

*Robert J. Farrell,* Control Engineer, Reliance Electric & Engineering Co., Cleveland, Ohio, a 1944 graduate of Fenn College.

*Stanley P. Freedman,* Plant Manager, Maryland Cup Co., Baltimore, Md., a 1942 graduate of the University of Maine.

*Donald A. Forbes,* Chief Engineer, Fraser Companies Ltd., Edmundston, N. B., Canada, a 1934 graduate of the University of Saskatchewan.

*George Gall,* Director and Manager, Showalhaven Mill, Wiggins Teape & Nash Paper Mills Pty. Ltd., Bomaderry N. S. W., Australia.

*Andrew J. Gard,* Chemical Development Engineer, Sersenes, Inc., Framingham, Mass., a 1939 graduate of the University of Akron, Ohio.

*James L. Henderson,* Chief Engineering Dept., Champion Paper & Fibre Co., Pasadena, Texas, a 1937 graduate of The Rice Institute.

*Arthur E. Irvine,* Development Engineer, Bakelite Co. Div., Union Carbide & Carbon Co., New York, N. Y., a 1942 graduate of Detroit Institute of Technology.

*Joseph Kaltenbach,* Chief Chemist, Chemische Fabrik Hoesch K.G., Duren, Germany, a 1931 graduate of the Technical University, Aachen, with a Ph.D. degree.

*Edwin J. Kirkman,* Technical Director, S/A Industrias Votorantim, São Paulo, Brazil, a 1934 graduate of the College of Technology, Manchester, England.

*Karl T. Kraner,* Sales Application Research, Atlas Powder Co., Wilmington, Del., a 1942 graduate of Rutgers University.

*F. Otto Kreissler,* Chief, Pulp & Paper Section, Lurgi Gesellschaft für Chemi und Huttenwesen m. b. H., Frankfurt/Main, Germany.

*Walter A. Luce,* Metallurgist, The Duriron Co., Inc., Dayton, Ohio, a 1943 graduate of Ohio State University.

*William G. Macmillan,* Research Director, Indian Jute Mills Association Research Institute, Calcutta, India, a 1925 graduate of Aberdeen University with a Ph.D. degree.

*Francis X. Manogue,* Assistant Superintendent, Gilbraltar Corrugated Paper Co., Inc., N. Bergen, N. J.

*Raymond E. Marsh,* Project Engineer, Walter Kidder Construction Co., Houston, Texas, a 1931 graduate of the University of Maine.

*Joseph K. McConomy,* Mill Manager, Gaspesia Sulphite Co. Ltd., Chandler, P. Q., Canada.

*Robert H. Nitz,* Student, Western Michigan College, Kalamazoo, Mich., a 1952 graduate of Valparaiso University.

*Richard G. Powell,* Technical Service Representative, Mississippi River Chemical Co., St. Louis, Mo., a 1951 graduate of Iowa State College.

*Robert C. Putnam,* Chief Chemist, U. S. Testing Co., Hoboken, N. J., a graduate of Boston University and Harvard University with a Ph.D. degree.

*Johan C. F. C. Richter,* General Manager, AB Kamyr, Karlstad, Sweden, a 1924 graduate of the Technical University of Norway.

*Frederick Schindler,* Technical Representative, Petroleum Specialties Ltd., London, England, a 1948 graduate of Rensselaer Polytechnic Institute.

*Edward M. Simon, Jr.,* Technical Service Representative, Atlas Powder Co., Wilmington, Del., a 1943 graduate of Drexel Institute of Technology.

*Mortimer Simons,* Paper Chemist, Whiting Paper Co., Holyoke, Mass., a 1947 graduate of Rhode Island State College.

*Rodman B. Teeple, Jr.,* Technical Representative, Hercules

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Powder Co., Wilmington, Del., a 1948 graduate of Lehigh University.

*Herschel L. Vallandigham,* District Manager, Dicalite Div., Great Lakes Carbon Corp., Chicago, Ill.

*Ned Varner,* Assistant Superintendent, Union Bag & Paper Corp., Savannah, Ga., a 1949 graduate of Alabama Polytechnic Institute.

*Raymond J. West,* Vice-President in Charge of Production, The Stevens Paper Mills, Inc., Westfield, Mass.

*James B. Whitley,* Assistant Technical Director, Clay Div., J. M. Huber Corp., Huber, Ga., a 1938 graduate of the University of Georgia.

*Zina A. Wise, Jr.,* Sales, Griffith Rubber Mills, Portland, Ore. Attended Oregon State College and Portland University.

## *TAPPI Notes*

*R. H. Atwood,* formerly of the Penobscot Chemical Fibre Co., is now with the Standard Lime & Cement Co., Baltimore, Md.

*Alexander Babin,* formerly with the Solo Cup Co., is now Engineer for the Crown Zellerbach Corp., Portland, Ore.

*R. Munden Bishop,* Manager of Paper Chemicals Sales and Service for Hercules Powder Co. (Canada) Ltd., has moved his office from Burlington, Ont., to Montreal, P. Q.

*Walter C. Bloomquist* is now Manager of the Application Department of the General Electric Co., Philadelphia, Pa.

*Richard Boehm,* formerly student at The Institute of Paper Chemistry, is now Research Chemist for Kimberly-Clark Corp., Neenah, Wis.

*Frank A. Butler,* formerly student at the University of Maine is now a Development Engineer in the Paper Service Division, Eastman Kodak Co., Rochester, N. Y.

*Percy J. Cox* is now Technical Supervisor of the Consolidated Water Power & Paper Co, Wisconsin Rapids, Wis.

*Dante S. Cusi,* formerly of Aceite Casa S/A, is now President and Director of Cia. Ind. de San Cristobal S/A, Mexico, D. F.

*L. Edward DeLauter,* formerly of the Curtis Publishing Co., is now a Service Engineer for the West Virginia Pulp & Paper Co., New York, N. Y.

*Victor A. Denslow,* formerly of the Cities Service Oil Co., is now Senior Salesman with Spencer Chemical Co., Western Springs, Ill.

*O. W. Frost,* formerly of the Forest Fibre Products Co., is now General Manager of Oregon Fibre Products, Inc., Pilot Rock, Ore.

*F. X. Guimond* is now Assistant General Superintendent of the Kipawa Mill, Canadian International Paper Co., Temiskaming, P. Q.

*Frank B. Harlow* is now Assistant Manager of Mills of the Penobscot Chemical Fibre Co., Great Works, Me.

*Lynwood S. Hatch,* Vice-President of the Penobscot Chemical Fibre Co., Great Works, Me., has retired but will continue as a Director.

*L. Almeider Huerta,* Industrial Engineer of Celulosa Argentina S/A, Buenos Aires, Argentina, will be located at the Beloit Iron Works, Beloit, Wis., for a year's training as a design engineer of paper machinery.

*Gust (C. E.) Johanson* is now Superintendent of the Sulphite Division, Penobscot Chemical Fibre Co., Great Works Me.

*Edward W. Keith* is now Manager of Mills for the Penobscot Chemical Fibre Co., Great Works, Me.

*William F. Kruschka,* formerly of the Clifton Paper Co., is now Plant Engineer for the Manistique Pulp & Paper Co., Manistique, Mich.

*Edward F. Libby,* General Superintendent of Maintenance and Construction for the West Virginia Pulp & Paper Co., has retired due to ill health.

*Robert I. Mason,* Service Engineer for Hercules Powder Co.

Ltd., has been transferred from Burlington, Ont., to Montreal, P. Q.

*Frank P. Morrison* is now Superintendent of the Soda Pulp Division, Penobscot Chemical Fibre Co., Great Works, Me.

*Freeman S. Perry* is now Acting General Manager of the Ward Paper Co., Merrill, Wis.

*John C. Rice* is now Technical Director of the Lowe Paper Co., Ridgefield, N. J.

*Edward J. Romay* (Romatousky), formerly with the Barrett Division is now Vice-President and Technical Director of Resi-Chem Corp., Swanton, Ohio.

*Frederick Schindler*, Technical Representative for Petroleum Specialties Ltd., has been transferred from New York City to London, England.

*Lloyd D. Shand*, of Monsanto Chemical Co., has been transferred from Cleveland, Ohio, to St. Louis, Mo., as Assistant Sales Manager for Paper Chemicals.

*Arthur O. Spierling*, Manufacturing Superintendent for the Hammermill Paper Co., retired on June 1.

*Robert W. Stoertz* is now Pulp Mill Superintendent for the West Virginia Pulp and Paper Co., Charleston, S. C.

*Edward J. Sullivan*, formerly of H. G. Craig & Co., Inc., is now in the Sales Department of The Bowaters Paper Co., Inc., New York, N. Y.

*Laurence P. Thompson*, formerly of Personal Products Corp. is now a consultant at Chestertown, N. Y.

*J. Edward Vivian* is now Director of Massachusetts Institute of Technology, School of Chemical Engineering Practice, Cambridge, Mass.

*Ivar Vestby*, formerly of Hunsfors Fabrikker, is now with A/S Forenede Papirfabrikker, Drawmen, Norway.

*Leo B. Wickstrom*, formerly of Industrias Klabin de Parana, is now Technical Manager of Ortvikens Sulfitfabrik, Skonsberg, Sweden.

*Robert J. Yaeger*, formerly of the Ansul Chemical Co., is now Sales Manager of the Great Northern Oil Co., St. Paul, Minn.

*Robert S. Young* is now Superintendent of Manufacture for the Hammermill Paper Co., Erie, Pa.

* * *

Ir. J. Tromp, Managing Director of Van Gelder Zonen N.V., has succeeded C. F. D. Beuker as the official representative of his company in TAPPI.

* * *

Frank W. Egan & Co. has moved its office and plant from Bound Brook, N. J., to 36 S. Adamsville Road, Somerville, N. J.

J. E. Rhoads & Sons has moved its executive offices from Philadelphia to Wilmington, Del.

## *Industry Notes*

PRODUCTION

In March the recovery of our economy from the low of last year continued as commercial and industrial activity persisted in its advance to a higher level.

The Federal Reserve Board Index of industrial activity, at 135, approached the 1953 high of 137, and the Gross National Product, a more inclusive measure, rose to an annual rate of approximately 370 billion dollars.

To meet the nation's large requirements for paper and paperboard, producers of these products have increased their output to a volume never before achieved. As a result, production in each of the first three months has represented an all-time high for the given month, and output for the first three months is estimated to have been 7,177,000 tons. This exceeds the previous high achieved in the second quarter of 1951, when the Korean War was in progress, by 2.5% and the first quarter of 1954 by about 10%. If, as many expect, the


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automobile and construction industries operate at reduced levels in the latter half of the year, and the pace of business activity is slowed, it would seem to follow that this industry too will produce at less than the current volume, and production for the year will be somewhat less than that arrived at by projection of the first quarter output.

While all major grades show an advance over last year, however, it should be noted that to a large degree the improvement has been concentrated in paperboard, building-board and newsprint, these three segments accounting for 73% of the increase over the first quarter of last year.

In March, production for each of the major groups was large with the result that output for the industry was at an estimated all-time monthly high of 2,577,000 tons.

The production of printing papers for the month is estimated to have been 331,000 tons. This was 11% more than in February and represented a 3% gain over March of last year when 322,000 tons were manufactured. The volume of new orders received during the month was larger than that of shipments, with the result that the tonnage represented by unshipped orders rose to 377,000 tons.

Fine paper mills continued to produce at a record pace as 135,000 tons were manufactured. By the end of the first quarter this group of mills had produced slightly in excess of 372,000 tons. This represented a gain of 14% over the first quarter of 1951, the record year for these mills, and a gain of 16% over the first quarter of 1954. For the third successive month, shipments were in excess of production, causing a further reduction in stocks on hand to 104,000 tons. New orders again were larger than shipments and by the close of the month unshipped orders had risen to 78,000.

The production of coarse paper continued its month to month advance in March as 323,000 tons were manufactured. This represented an increase of 10% over the previous month and a 6% advance over March of last year. For the year to date output of these papers was 918,000 tons, 5% more than in the record year of 1951 and about 5% more than in 1954. During the month new orders were approximately 20,000 tons larger than shipments, causing the backlog of orders to rise to 172,000 tons.

Tissue paper mills which, since the end of World War II, have, with a single exception, established a new production record each year, appeared well on the way to another such year as their March output of 148,000 tons caused the total for the quarter to be about 417,000 tons. This was 4% more than for the first quarter of 1954.

The production of newsprint also continued strong as output for the month amounted to 125,000 tons, the largest monthly domestic production of this paper in more than 20 years. In the first three months 345,000 tons were manufactured, 24% more than for the same period in 1954 and 32% more than for the first quarter of 1953.

Through the end of April this year United States mills turned out 93,078 tons or 24.6% more newsprint than in the first four months of 1954 while output in Canada also was 78,105 tons or 4.0% greater than in the corresponding period of last year, thus the continental increase totaled 171,183 tons or 7.4%.

Paperboard was produced in record volume in March as an estimated 1,207,000 tons were manufactured. For the year to date this segment of the industry has been chiefly responsible for the industry advance over last year, accounting for about 50% of the added tonnage. During the month the volume of new orders received amounted to 1,304,000 tons, causing the backlog of orders to rise to 449,000 tons at the close of the month.

### Pulpwood

Pulpwood receipts for January and February totaled 5,513,000 cords, an increase of 732,000 cords above last year. Domestic receipts increased 674,000 cords and imports 58,000 cords.

Consumption of pulpwood for the first two months of this year was 5,192,000, an increase of 615,000 cords. Consumption can be expected to continue at a high rate in view of anticipated high-level wood pulp production.

Inventories continued to increase, totaling 5,563,000 cords at the end of February, 348,000 cords more than at the end of January, but 271,000 cords less than at the close of February 1954.

### Wood Pulp

Wood pulp production for the first two months of this year was 3,219,000 tons, an increase of 358,000 tons over production for the January-February period last year. This sharp increase can be attributed in part to the several new mills which came into production during 1954.

Record high paper and board production, estimated for the first quarter at 7,100,000 tons, was a major factor in substantially increasing wood pulp consumption in the first two month of this year above that for the comparable months in 1954. Consumption for January and February was 3,319,000 tons, an increase of 330,000 tons over the same period in 1954.

Imports for January and February totaled 308,913 tons, a decline of 7,721 tons under imports for the comparable months in 1954. The sharp decline in imports in February from overseas, principally from Sweden, was due in part to the severe winter conditions impeding shipments from usual "open water" ports. Imports from Canada, on the other hand, showed an increase of 13,562 tons.

Exports have continued at a high rate and for the first two months of this year totaled 97,000 tons, an increase of 63,000 tons. Expectations are that exports will amount to over a half a million tons this year.

Inventories at the end of February were 656,000 tons, a decline of 10,000 tons under inventories at the end of January. Pulp mill inventories at the end of February were 168,000 tons and inventories at paper and board mills totaled 488,000 tons.

### Waste Paper

Receipts of waste paper for January and February are reported as slightly above last year, 1,301,000 tons as against 1,249,000. With continuing high board production, receipts can be expected to remain at a fairly substantial level.

Waste paper consumption for the first two months of this year has been averaging about 20,000 tons a month above the comparable months of last year and, with estimated paper and board production in March at a record high, consumption continued strong through the first quarter. Two months consumption amounted to 1,363,000 tons as against 1,288,000 tons for January–February last year.

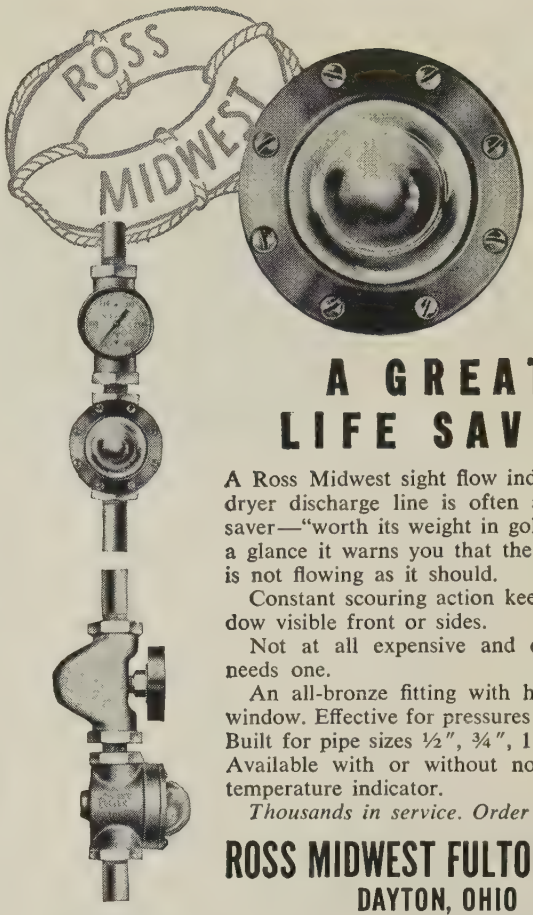
### Austria

The year 1954 was a special year for the Austrian pulp and paper industry, inasmuch as it marked the completion of the Austrian Government's four-year investment program in this industry, which was financed largely by FOA funds.

The last projects of the long-term investment program of the Austrian pulp, paper, and cardboard industry were completed in 1954, as a result of which the capacity of this industry increased by about 50% as compared with 1949.

Because of the large demand for pulp, paper, and cardboard on the domestic and foreign markets, the monthly output of this industry rose steadily during 1954, and for most of the period from July to October almost all mills operated at close to capacity.

A comparison of 1954 production figures with those of 1953 shows that total mechanical and chemical wood pulp production increased by more than 110,000 short tons or 24%. About two-thirds of the additional output were consumed by the domestic paper and cardboard industry as well as by the two rayon mills in Austria, while the remaining third was ex-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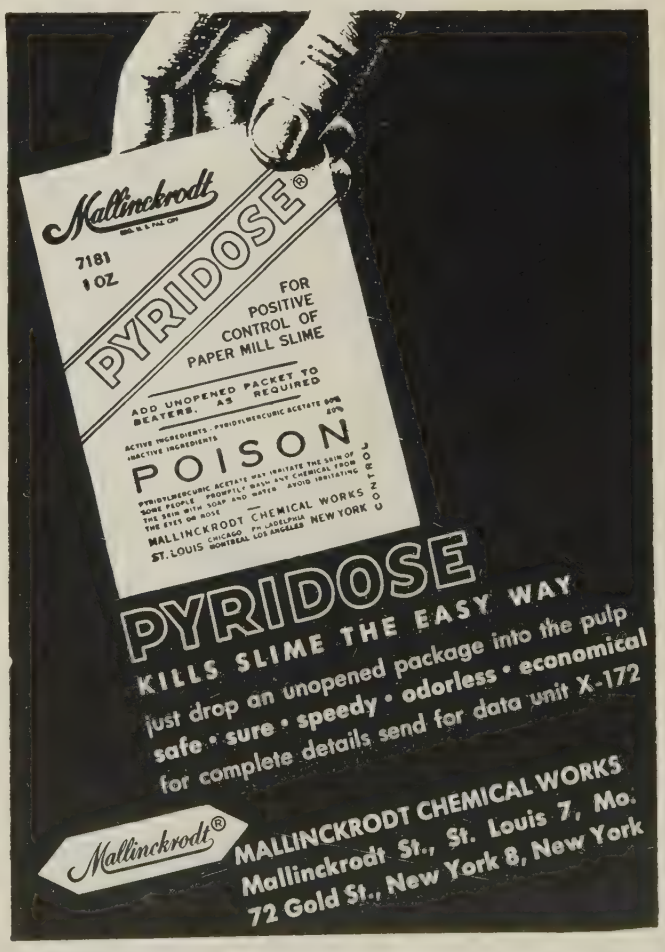
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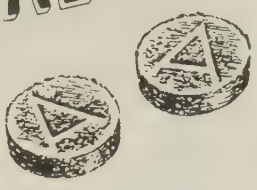

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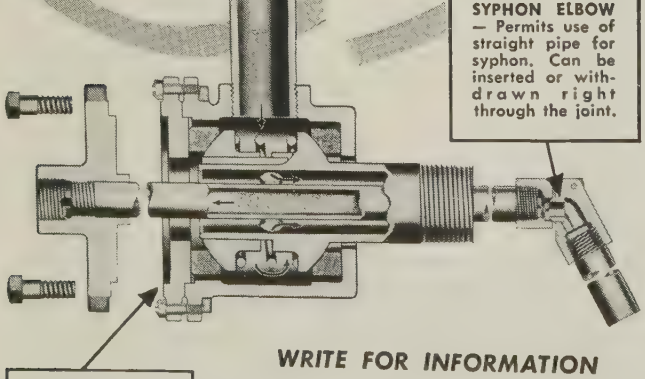
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ported. In 1954, total domestic consumption of wood pulp was 22% higher than in the previous year while wood pulp exports rose 20%.

Annual production of cardboard and paper exceeded the 1953 output by about 91,740 short tons, or 23%. In this case more than half of the additional output was exported. Total paper and cardboard exports increased by 27%; sales on the domestic market rose 24% as compared with 1953.

While the volume of exports of wood pulp and paper and cardboard in 1954 were, respectively, 20 and 27% higher than in 1953, the value increased by 40 and 41%, respectively. This was due to an improvement in the price situation on the export markets, which had been very unfavorable in 1953, and to an improvement in quality. In spite of higher export returns, however, the prices obtained on foreign markets for most types of Austrian paper were lower than domestic paper prices.

One of the exceptions to the above rule was newsprint, the average export price of which rose by 20% from about 3015 schillings ($116) per ton in 1953 to 3607 ($139) in 1954. The domestic price of newsprint, on the other hand, after rising 20% to 3400 schillings ($127) per ton in March 1954, was held down to that level for the remainder of the year by the Government.

The aforementioned increase in the domestic newsprint price had been due to increases in costs of materials: foreign coal, sulphur, pyrites, paper machine felt, kaolin, and several other auxiliary materials, plus the primary material, wood pulp. The following is the background of the increase in the domestic price of wood pulp:

As a result of a sharp increase in domestic pulpwood prices, certain cellulose producers, found it impossible to maintain their cartel prices, and the cellulose producers' cartel was dissolved at the beginning of 1954. In March 1954, the average domestic prices for unbleached and bleached sulphite pulp increased from 3200 ($123) and 4000 ($157) schillings, respectively, to 3600 ($139) and 4400 ($169) schillings, and by January 1955 (as a result of further increases in pulpwood prices) to 3950 ($152) and 4700 ($180) schillings respectively.

Because of the fact that higher prices could be obtained on foreign markets than on the domestic market, there were some difficulties in the supply of those domestic paper mills which have no pulp mills of their own, since independent pulp producers increased their exports at the expense of the domestic supply. However, these difficulties were soon overcome by internal arrangements of the pulp and paper industry.

A greater difficulty, lasting throughout 1954, arose from the steadily increasing exports of pulpwood, which resulted in increasing shortage and rising prices on the domestic pulpwood market. The high demand for wood elsewhere in Europe had caused this boom in Austrian wood exports, which increased 50% from 4 million to 6 million cubic meters—between 1951 and 1954. From March to December 1954, domestic pulpwood prices increased 50%. At the same time, as exports of those kinds and sizes of wood needed by pulp mills rose sharply in 1954, Austrian pulp mills were forced to use wood usually bought by sawmills, or other types of wood not previously used for pulp production, such as cheap wood slabs and the waste of sawmills and the woodworking industry. Ths use of sawmill wood meant that certain types of wood were used uneconomically; furthermore, since sawmill wood is more expensive than pulpwood, and since pulp mills had to outbid sawmills, it caused a further increase in the production costs of pulp mills.

Basically, the existing price conflict between the pulp and paper industry and the wood owners stems from the following: wood owners attempted to obtain nearly the same high prices on the domestic market as they had been able to get on export markets. Pulp mills usually passed on these increases to the domestic paper mills only reluctantly and infrequently, because of their dependence on the latter. Where pulp prices

were thus increased, the paper mills were not allowed to increase domestic paper prices, for the reason mentioned above. This is illustrated by the fact that, from March through December 1954, pulpwood prices increased about 50%, average wood pulp prices only about 7%, and paper prices not at all.

However, at the end of 1954, as wood prices continued to ascend, the paper industry approached the government with the request that the government either impose a domestic price ceiling on wood or permit an average 12.6% increase in domestic paper prices. The government chose another alternative; it imposed severe restrictions on exports of round timber and sawn lumber and, subsequently, lifted the import duties on wood. On March 2, 1955, the government finally agreed to an 8.8% increase in domestic newsprint prices—from 3400 ($121) to 3700 ($142) schillings per ton, effective March 15, 1955.

Prices of other kinds of paper remained unchanged because the government considered the 8.8% increase in newsprint prices, together with the wood export restrictions and the other aforementioned measures, adequate to stabilize the situation.

The rise in wood prices had, of course, also affected the cardboard industry. In mid-November, when raw material costs of cardboard mills were already 30 to 40% higher than in the spring, this industry raised its prices by an average of 10%. Thereupon cardboard-converting mills also increased their prices up to 10%. This relatively large increase in prices of finished cardboard products was to compensate not only for the higher cardboard price but also for wage increases, which had been granted by this industry during the second half of the year. This increase had no adverse effect on Austrian consumption; in December 1954 and January 1955, cardboard sales in the domestic market were 770 and 1320 short tons higher than in the corresponding months of 1953. (It may also be stated, incidentally, that the increase in newsprint prices which became effective on March 15, will not mean a decrease in domestic paper consumption.)

*Wood Pulp Production*

Production of mechanical pulp in 1954 amounted to more than 152,240 tons, an increase of 20% over 1953, and 68% over 1949, when production amounted to about 90,750 tons. This large increase was achieved between 1949 and 1953 through new construction or modernization of wood preparation plants, installation of 14 new grinders, construction of silos and other investments which were carried out with the financial and technical assistance of the United States. The remarkable increase in productive capacity from approximately 110,000 tons in 1949 to 154,000 tons in 1954 was necessary in order to provide an adequate supply for the Austrian paper and cardboard mills, which sharply increased their capacity during those four years.

The largest investments in the chemical pulp industry were made in the sulphate pulp sector. Prior to these investments, Austrian production of sulphate pulp and sulphate paper was relatively small in proportion to total pulp and paper production. In 1937 sulphate pulp production amounted to only 24,970 tons, or 9% of the total output of paper pulp. Since in 1937 the consumptive capacity of the Austrian sulphate paper mills was only 16,500 tons, the surplus sulphate pulp had to be exported. At the same time, however, the annual output of 16,500 tons of sulphate paper was insufficient to cover domestic requirements, making it necessary to import additional quantities from Sweden and Finland.

No investments were made during the war, and domestic requirements for sulphate paper increased in the postwar period, so that the discrepancy between supply and demand for sulphate paper constituted a serious problem. For these reasons, the expansion of existing sulphate pulp and paper capacity was given particular attention in planning the long-term investment program of the Austrian pulp, paper, and cardboard industry. In view of the large domestic and ex-


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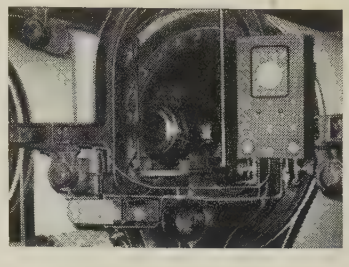

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port demand for sulphate pulp and paper, the one large sulphate pulp and paper mill in existence was expanded and a second large mill built. As a result of these two projects, which were completed in 1953 and 1954, productive capacity increased from about 27,500 tons in 1949 to about 88,000 tons in 1954. Actual production in 1954 amounted to almost 81,400 tons, close to 110% higher than 1953, when the new sulphate mill was not yet completed, and almost 370% higher than 1949, before the investment program started.

*Exports*

In 1954, Austrian wood pulp mills exported 151,344 tons, or 27% of their annual output. This quantity was about 20% higher than in 1953 and 106% higher than in 1949. As a result of the large expansion of wood pulp production during the same period, this increase in exports did not involve a reduction in domestic supply; on the contrary, the greater part of the additional output since 1949 was made available to domestic paper and cardboard mills.

In 1954, the largest quantities of Austrian pulp of all kinds were shipped to Italy; second in importance was Western Germany. Relatively large quantities were also exported to Switzerland (primarily bleached sulphite and unbleached sulphate) and France (largely bleached sulphite).

*Imports*

Imports of wood pulp in 1954 totalled more than 14,300 short tons, as compared with imports of about 88 and 1980 tons in 1949 and 1953, respectively. This sharp increase is to be attributed to the tense supply situation which temporarily existed for certain independent paper and cardboard mills. Because of import liberalization these mills were able to obtain pulp from abroad when it was not available on the domestic market. In spite of this sharp increase in 1954, imports remained small as compared with total domestic consumption.

The largest quantity of pulp was imported from Western Germany; it consisted largely of dissolving pulp. The quantities imported from other countries such as Finland, Great Britain, Italy, Sweden, and Yugoslavia were negligible.

*Paper and Cardboard Production*

During the past four years, investments in paper mills included the installation of modern stock preparation plants for 29 paper machines and of five waste paper preparation plants. Twenty paper machines were rebuilt and thirteen new ones installed; all these new machines have modern fiber recovery equipment. In addition to investments in paper production, 29 paper processing departments in paper mills were modernized. (Some of the new paper machines were originally intended to replace old and inefficient machines. However, because of the export boom, all machines remained in operation.)

Annual production capacity in 1954 amounted to about 440,000 tons as compared with 385,000 tons earmarked in the investment program and as compared with a capacity of approximately 291,500 tons in 1949. Since largely newsprint and cheap wrapping paper are being produced on the old machines, mechanical pulp capacity also had to be kept higher than originally planned. As soon as the current market situation eases this old production equipment for paper and pulp will be taken out of operation, which will cause a decrease of capacity, but also a decrease of production costs.

The total paper output in 1954 amounted to almost 401,720 tons exceeding the output of the previous year by almost 77,000 tons or 23%. As compared with 1949, the increase amounted to 154,00 tons or almost 63%. The largest increase (100%) over 1949 was in the production of special paper; i.e., thin paper grades, such as cigarette paper, tissue paper, M. G. cap, etc., where important investments were made in an attempt to increase specialization of Austrian paper production. However, the production of other grades also rose more than 50% over 1949. In the case of sulphate wrapping paper (which prior to investments had been produced solely by one large mill) a former sulphite paper mill rebuilt one of its machines and started production of sulphate wrapping paper.

Investments in cardboard mills, most of which are small, covered the modernization of their power and steam installation, the building of modern drying plants (in order to make them more independent of changes in weather), as well as the installation of new and the modernization of old cardboard machines. Annual capacity is estimated to have increased from about 82,500 tons to 93,500 tons between 1949 and 1954. During the same period actual production rose from roughly 57,970 tons to 85,250 tons, an increase of 47%. The output of machine-made cardboard increased most sharply, in comparison with other types. In this sector of cardboard production, two existing machines have been modernized and one completely new machine with an annual capacity of about 13,200 tons has been installed since 1949.

*Exports*

Following the 1952 slump, Austrian paper exports have been steadily on the increase since mid-1953, and it is believed that the 1954 boom will continue through 1955.

Total annual exports in 1954 amounted to 231,196 tons, which represents a 27% increase over 1953 and an increase of more than 128% as compared with 1949. This rise covered all types of paper; the largest expansion occurred in wrapping paper exports, largely as a result of the increase in Austrian sulphate paper capacity.

As in previous years, Austrian paper was sold to about fifty countries. As a result of the investments made during the past years, the Austrian paper industry was in a position to compete successfully with foreign producers. In this connection, it may be pointed out that during 1954 Austria was competing for European markets not only with Scandinavian producers, but also, for the first time, with Canada.

In spite of the large increase in both paper and cardboard exports, sales to the domestic market were also increased by more than 20%. Based upon domestic sales and import figures, it is estimated that Austrian paper and cardboard consumption increased from approximately 57.2 lb. per capita in 1953 to about 66 pounds in 1954. While 53% of the domestic paper and cardboard production was exported in 1954, a further increase of the Austrian per capita consumption to about 110 pounds (which is considered to be the West-European average) would involve a reduction of exports to approximately 20% of the present production.

*Imports*

Total paper imports in 1954 amounted to about 3190 tons, about 1210 tons less than in 1949, but 1540 tons more than in 1953. The fact that paper imports in 1954 were larger than in the previous year when the domestic capacity was considerably lower needs some explanation. This explanation is given by a comparison of the types of paper imported in 1949, 1953, and 1954. It shows that in 1949 more than 3938 tons, or 88% of the total quantity of paper imported, consisted of wrapping paper (largely sulphate wrapping paper). As a result of the expansion of domestic production of this kind of paper, imports had decreased to about 750 tons in 1953, and in 1954 amounted only to about 382 tons. The greater part of the 1954 imports consisted of parchment and other greaseproof paper, which is not produced in sufficient quantities in Austria. Imports of book and writing paper show no significant change in the three years under comparison, only special types of paper, such as art printing paper, being purchased abroad. However, a sharp change is noted in imports of special paper. Although domestic production of various kinds of special paper, such as cigaret paper, tissue paper, etc., had also been expanded between 1949 and 1954, imports

increased from 198 tons in 1949 to about 506 tons in 1953 and almost 2,398 tons in 1954. About 2200 tons of the latter were special colored paper, which is not available in Austria in sufficient quantities.

To some extent, the increase in total paper imports in 1954 was the result of the liberalization of paper imports which became effective at the end of 1953. Because of the export boom, paper mills were temporarily not in a position to fill domestic orders in the time requested; in such cases, customers may have preferred to buy the required quantities abroad, in spite of the existing domestic production. By far the largest quantity of foreign paper was purchased in Western Germany.

### British West Africa

Plans for the development of several new industries in the Gold Coast were made known by the Industrial Development Corporation. Survey work by a firm of London consultants on a paper mill will start shortly. The estimated cost of the mill is set at £500,000 ($1,425,000).

### East Germany

As a result of inadequate cellulose production and deterioration of the equipment of paper factories, the paper supply has been reduced. During February the paper allocation to publishers allegedly was cut by 50%. State owned industry and trade were ordered to reduce paper consumption by 90%. Only printers and publishers of political propaganda leaflets seem to be free from restrictions.

Paper factories reportedly have dismissed 1400 employees since January. Their production quotas for the first quarter were reduced by 30%. Even some paper export contracts have had to be cancelled. This is especially true of exports of high quality paper products.

While these reports are unconfirmed, the paper shortage seems to have become chronic.

### Finland

The Fragmit building board is an original Finnish product, manufactured from fibers of reed stalks with inorganic binding material. The reed stalk is composed of an outside hard layer and an inside layer of a woody structure. The reed stalks are split lengthwise and the inner woody part, which in whole reed stalks can constitute a seat for different kinds of insects, is impregnated with an inorganic, bacteria-killing, binding substance. In contrast to wood, the hard reed stalks are not affected by the chief constituents of the binding medium, namely cement and lime. The consistency of volume of the fiber prevents movement in the Fragmit board, thus preventing cracks in plastering, and the natural resistance of the fiber against biological destruction results in an enduring inner structure and stability. A method of fixing to prevent cracks in plaster caused by shrinkage in the carrying frame has been tested, reportedly with the best possible results.

The Fragmit boards have purposely been made denser and heavier than most other building boards to increase durability, sound and thermal insulation and to provide greater stabilizing effect on the structural frame. Furthermore, details of construction have been worked out in which the consumption of materials and nails is extremely low. The manufacturers claim for such a building a long life provided by fire-resistant and maintenance-free building material.

Total Finnish production of paper in 1954 amounted to 850,000 tons, of which 456,000 tons were newsprint and 165,000 tons kraft paper. Total production in 1953 reached 745,000 tons; exports rose to nearly 700,000 tons compared with 625,000 in 1953.

### India

The production of paper in India has steadily increased during the years 1950 through 1954. From 119,798 tons in 1950 production rose to 145,107 tons in 1951, 151,257 tons in 1952, 153,674 tons in 1953 and 170,861 tons in 1954.

Consumption has risen nearly 50% as a result of an increase in literacy and an improvement in the standard of living.

There are 21 paper mills in India at the present time, having an installed capacity of 165,000 tons a year. With the implementation of the development plans envisaged for the industry, the installed capacity is expected to rise to 407,000 tons by 1960–61. The capital invested amounts to Rs. 217.2 millions ($45,612,000). An additional investment of Rs. 143 millions ($30,030,000) is envisaged in the expansion and modernization program.

India's output of paper is still short of requirements, officially estimated at 220,000 tons a year; the gap is filled by imports, which in 1954 totaled approximately 145,200 tons. The demand for paper in India should further increase as progress is made in improving economic conditions and in extending literacy.

Under Madras State's second Five Year Plan, a paper mill has been sanctioned for Papanasam (Tirunelveli District) and an additional mill in the Nilgiris is under construction.

### Mexico

The outstanding industrial endeavor of the state, the U. S. $25 million cellulose factory at Cuauhtemoc, continued construction more or less on schedule. Construction was to be completed in August, 1955 and production to begin in December, 1955. According to the manager of Bosques de Chiluahua, S. A., which lumber company is tied in with the plant, Celulosa, S. A., will produce 44,000 to 46,200 tons of cellulose annually, 50% unbleached and 50% bleached kraft.

### Sweden

Despite increased production costs resulting from higher pulpwood prices and a 7% average wage improvement for pulp workers, the Swedish pulp producers seem to be observing considerable restraint in their pricing policy in anticipation of growing North American competition in the European pulp market during 1955. So far, however, Swedish pulp producers appear unable to satisfy the growing European pulp demand. In 1954 this demand absorbed a considerable part of North America's exportable surplus, apparently without injury, on balance, to the export business of the Swedish pulp producers. Local industry circles predict an increasing rate of papermill operations in Europe during 1955, thus creating a pulp demand in excess of the tonnages North America may be expected to ship to Europe this year.

One of Sweden's largest newsprint mills will be built by the Swedish Cellulose Co. at Sundsvall, center of the country's foremost pulp and sawmill district. It will be constructed in two stages. The first one, scheduled to be completed in 1958, will result in a production capacity of 70,000 tons. Later on the output will be increased to 140,000 tons, which is more than the capacity of Sweden's currently biggest newsprint mill. The Swedish Cellulose Co., which is the country's largest industrial concern in the forestry field, will also expand or modernize many of its pulp mills. During the next three years the company's largest unit, the Ostrand sulphate mill near Sundsvall, will increase its bleaching capacity from 50,000 to 120,000 tons annually, that is, the mill's total output of sulphate pulp.

### Switzerland

The Federal Forestry Inspectorate (Eidgenossische Inspektion fur Forstwesen) which is the controlling agent for Swiss forests, applies a very conservative policy which generally aims at maintaining the status quo in terms of production. During the war the Swiss timber reserve was not actually drained but some extra felling was required. The present policy is one of reconstituting these reserves. For example,

in the case of the City of Bern, in forests which ought to yield (marked trees) an annual 20,000 cubic meters, only some 16,000 cubic meters are felled. The same applies to the majority of other cantons with the result that, while the area of forests remains about the same, timber reserves are on the increase. It is safe to state that the Swiss policy as regards forests is more conservative than in other European countries.

According to Swiss experts, wood consumption in Europe remained more or less constant, at least during the last few years. The use of firewood is on the decline, but more paper pulp and wood for construction is required. Then too, the industrialization of Eastern Europe and especially of the Soviet Union is continuing. This necessitates more barracks, houses, cellulose, packing cases, etc., and the smaller postwar exports of Russian timber appear to be the result of this industrialization

European forests have been over-exploited for centuries and, while consumption appears to be stable, supply remains limited. Before the war, Poland and Czechoslovakia had been regular suppliers of Switzerland, but today the Swiss cannot rely on regular imports from these two countries. At present, exports from Western Germany and Austria are subject to a system of export quotas. Yugoslavia, after decimating some of its forests, has become more careful, and the Swiss state that the quality of Yugoslav timber is not what it used to be, the best having been exported to cover the need for foreign currencies. After the postwar exploitation of the forests of the German Schwarzwald in 1946–49 ended, it has been difficult for the Swiss to find a regular and sufficient supply of timber, especially of "Nadelrundholz," i.e., of round timber of coniferous trees.

The decline of the wood supply from Northern and Eastern Europe has had farfetching consequences on the timber market in Western Europe. Swiss negotiators who have difficulties in obtaining timber from Iron Curtain countries, believe that Western Europe will never be in a position to obtain from the satellites states substantial quantities of Nadelrundholz at competitive prices. They think that this item will, for the indefinite future, be in great demand not only in Switzerland but in Western Europe in general.

There is still another aspect to this problem; today European countries prefer to sell sawn lumber rather than round timber—this in order to provide more profits for their own sawmills. The Swiss naturally prefer to purchase round timber, or timber only hewn or squared by the ax.

### United Kingdom

The general improvement in trading conditions in most industries of the United Kingdom during 1954 led to a considerable increase in the demand for paper, board, and paper products, and production of all the main classes of paper and board rose. The complete derationing of food in the United Kingdom also accounted for an increased demand for wrapping and packaging paper, as well as for cardboard containers and cartons.

During 1954, 2,121,373 tons of wood pulp for all purposes were imported into the United Kingdom compared with 1,774,953 tons in 1953.

As in past years Sweden was the main supplier of wood pulp to the United Kingdom, sending 773,368 tons compared with 711,212 tons in 1953. Norway was the next largest supplier sending 439,995 tons and Finland who sent 436,548 tons. A particular point of interest is the fact that imports of wood pulp from the United States to the United Kingdom rose from 20,623 tons in 1953 to 103,437 tons in 1954.

Prices of imported wood pulp from Scandinavia remained on much the same level throughout the year. This price stabilization is believed to have been due to the increased imports into the United Kingdom of wood pulp from the United States and Canada during the year made possible by the increased currency allocations authorized by the Government for the purchase of wood pulp from any source, including the dollar area. Until recently the Scandinavians had virtually a monopoly of the wood pulp market and while it is believed that the United Kingdom paper manufacturers will, for traditional reasons, continue to buy their pulp from Scandinavia, the competition being felt from North America is expected to have the effect of keeping prices at an even level.

The recent increases in the currency allocations have led to speculation in the paper trade that the United Kingdom Government is considering freeing the United Kingdom paper industry from control. The opinion in the trade is that the growing demand for paper, the low stock position, and the increased capacity of the paper mills due to the installation of new plant, etc., makes it necessary for the industry to have additional supplies of wood pulp. However, at the end of the year the paper industry was still subject to Government control, and although the trade is of the opinion that this control could be abolished, it is thought that such a step will not be taken while there is still Government control of newsprint imports into the United Kingdom.

The year 1954 ended on a boom note and the paper industry of the United Kingdom is of the opinion that the satisfactory trading conditions now being experienced will continue for some time. The increased paper prices which were announced at the beginning of 1955 are expected to have very little effect on the demand for paper, and unless there are any labor or wage problems the year looks like another very good one for the industry.

### West Germany

As a result of full production and high consumption, the pulp and paper industry recorded an excellent year during 1954. Production was the highest since the war and, during the last half of the year, consumption exceeded that prior to the war. Increases in the costs of raw materials, resulting in repeated price rises late in the year, were the only dark spot in a generally bright picture.

Increasing domestic demand also caused a post-war peak in paper and pulp imports, since internal production, in spite of its progress, does not fulfill demand. Rising prices for European pulp and paper caused many German buyers to turn to Canada and the United States for pulp and newsprint. While exports also increased during the year, they were still largely confined to special orders and high quality products.

Increased employment coincided with increased production throughout the year. The number of employed in the industry rose from 63,384 in January 1954 to 67,831 in November. The industry led all German industry in hours worked per week per employe. In November 1954, when the average German industrial worker put in 49.1 hours per week, the workers in the pulp and paper industry worked 52.0 hours. In some places the figure went as high as 58 hours per week.

It appears likely that the growth of the pulp and paper industry will continue in 1955, probably at a reduced rate, however. The production index rose to 152.2 (1936—100) in January of this year, about 16 points higher than in January 1954. While the volume of orders was somewhat below December 1954, full production seems probable during the next few months, at least. Such optimism is also supported by the prediction of the Federal Minister of Economics that the gross national product will rise another 8% in 1955. Rising prosperity will, in all likelihood, stimulate an increase in per capita consumption.

As in 1954, the most critical problem faced by the industry is prices. Spokesmen of the industry stress that paper prices will not go up if the cost of fiber wood does not rise. On the other hand, price reductions can not be expected in any case. Since wood prices were generally stable during the first quarter of 1955, paper prices will probably not change, at least until June. Wood prices now, however, are beginning to ascend and also Scandinavian pulp prices have risen during the first

part of the year. Continuation of this trend would undoubtedly produce higher paper prices later in the year.

Increased paper consumption will probably result in increased pulp and paper imports. Imports of half-bleached sulphate pulp will increase especially, since the Federal government has submitted draft legislation to decrease the import duty from 7 to 2%.

The industry, as a whole, is greatly interested in the discussion on a new German cartel law. It favors a law based on the "abuse" principle rather than the "prohibition" principle. The Treuhandstelle points out that the pulp and paper industries in other European countries are organized into cartels and, for reasons of international competition, the German industry will be weakened if the present prohibition of cartels is continued.

*Artificial Fiber*

1955 promises to be another successful year for the West German artificial fiber industry.

Although no unusual increases in production or sales are foreseen in the cellulose fibers branch, stocks are at normal levels and the factors which have favored the industry during the past two years, such as the high rate of housing construction, the expanding output of vehicles and the generally high level of industrial activity, are expected to continue their upward trends and to sustain a high level of demand, particularly for rayon filament. In addition, barring another year of unusually bad summer weather, demand from the clothing industry should also increase under the stimulus of generally higher wages and a rising standard of living in West Germany.

The production of fully-synthetic fibers is expected to continue its rapid increase of the past several years and trade sources estimate that total production will exceed 10,000 metric tons. The demand for Perlon filament will continue to absorb all of the domestic production and efforts to create or enlarge markets for Perlon staple and the other fully-synthetics will continue. Acrylic fibers will account for a much larger share of the total production and sales.

The prospective rearmament of West Germany is a new factor which must be considered in assessing the future development of the artificial fiber industry although its effects are not likely to be felt to any appreciable degree in 1955. While it is difficult to see how the additional demand created by the new military forces can be anything but a stimulus to production in the industry, trade sources questioned on this point feel that any such new demand will be negligible and, in view of the current full-capacity operations, are much more concerned with possible disruption of the present well-established and satisfactory channels of trade. Furthermore, fears are expressed that the industry will be adversely affected by the shortages of skilled manpower and the difficulties in procuring new machines and equipment which are felt to be likely consequences of the rearmament.

As was the case in 1954, the successful development of the industry during 1955 will be dependent to a large extent on a high level of exports. Even though competition in foreign markets is severe and prices are low, West German producers feel that the establishment and maintenance of reliable export markets are important to the stability of the industry and increased efforts in this field are expected.

In spite of the healthy state of the domestic industry, producers continue to complain about competition from low-priced foreign imports, especially viscose staple. Particular concern has been expressed about the possible extension of the liberalization of imports from the dollar area to additional types of artificial fibers, which it is feared, would result in a substantial increase in imports from the United States.

West German producers feel that they can ill-afford to fight such competition because of their continuing need for larger investments in new plant and equipment, especially for the development and production of fully-synthetics. However, unless further dollar liberalization takes place, no radical change in the import pattern is anticipated.

Central America

The establishment of a paper industry under the direction and control of five Central American republics was agreed to in principle recently.

The committee on Economic Integration for Central America also agreed in principle that the initial plant, after further study and survey, would be situated in the pine forest area of northwest Honduras.

Following discussion of a report on paper manufacture, Pedro Pineda Madrid, Acting Minister of Finance and Economy for Honduras, urged the report's adoption. The report recommended establishing the plant in the Lake Yojoa district near the Guatemalan border.

Enrique Delgado, Minister of Economy for Nicaragua, said his country agreed with the recommendation but added that in any contemplation of further paper manufacture, his country's potentialities should receive serious consideration.

Thus the first project in economic integration has been passed upon by the committee without the expected interference of nationalistic pressures on the part of the conferees.

The start of what might be a serious split in the committee appeared at a later session when Senor Delgado asked clarification on Government versus private enterprise efforts in the over-all program. He pointed out that in the paper manufacturing project as well as others, capitalization must be considered.

Most of this capitalization necessarily would involve private funds, he said. He asked that at this early stage some clear idea be given the Committee on the extent of participating Governments' investment and control and on the role of private enterprise.

Israel

In the second half of 1954, the output of the Israeli Hadera paper mill was almost double what it had been during the first half, and the rate will again double during 1955.

The total output figures for 1954 according to grades are as follows:

| | *Tons* |
|---|---|
| Newsprint | 2831 |
| Kraft | 2108 |
| Woodfree | 1398 |
| Middlefine | 773 |
| Sulphite | 503 |
| Total | 7613 |

Owing to the initial technical difficulties, only 2447 tons of paper were produced in the first six months of 1954.

Of the 14,500 tons expected in 1955, 2500 tons will be newsprint, 6000 tons kraft and sulphite, and 6000 tons woodfree and middlefine.

Newsprint production, which is the least profitable, is thus to be reduced, and as a result part of the local Israeli requirements will have to be covered by imports.

Of the newsprint produced in 1954, 2447 tons were supplied to the organized dailies and weeklies, while the remaining 384 tons were sold on the general market.

The actual annual consumption of newsprint by the periodicals is estimated at 2500–3000 tons.

Over one-third (743 tons) of the kraft paper produced last year was supplied to the Haifa Nesher bag factory.

Several kinds of machinery were acquired recently by the Hadera company in order to make the increase of output possible.

Norway

The steady expansion since the end of the war of Norway's

pulp and paper industries is reflected in the 1954 production figures.

The forests and the rivers which can be harnessed for water power provide Norway with good, natural conditions for the favorable development and expansion of a pulp and paper industry.

The forests are not, of course, as large as those in other parts of the world, but the 17.2 million acres cover 23½% of the total area of the country. When it is realized that 65% of the country is composed of mountain districts and stretches of marshy ground, one can more readily understand just how predominant the forests really are.

To this must be added the fact that the Norwegian forests are situated in the northern coniferous districts, and that they furnish a product most adaptable to utilization by the pulp and paper industry.

For more than 50 years pulp and paper products—mechanical wood pulp, chemical wood pulp, and paper—have been dominant features in export statistics.

Today, the pulp and paper industry represents more than one quarter of all the exported goods of Norway. It also covers the domestic needs of paper and board with their innumerable applications. Norway is one of the European countries having the highest per capita consumption of paper, in excess of 60 kilos annually.

Norway's first paper mill was set up in 1698 using rags as raw material, but it was not until 1866 that the first mechanical wood pulp mill was established and it is from that time that the pulp and paper industry in Norway really dates.

In 1874 Norway got its first sulphate mill and in 1881 came the first sulphite mill.

In the years before the turn of the last century, many pulp and paper mills were erected and the pulp and paper industry became an important factor in the economic life of Norway.

At the turn of the century mechanical wood pulp production was of the order of 200,000 tons (always metric tons = 1,000 kilos.). Today, output is three times that quantity. The production of chemical wood pulp at the turn of the century was about 100,000 tons (at present it is five times that amount), while paper and board production, then only 60,000 tons, is now closer to 600,000 tons.

This development has not, however, been steady and continuous. The pulp and paper industry is based on export possibilities and the fluctuations on the international market have had considerable effect. Between the two wars there were hard times, while the last war also made its mark—not so much in direct material war damage as by a state of enforced stagnation due to the isolation of the country.

Since the end of the war enormous strides have been made despite the fact that the first post-war years saw the introduction of many import restrictions, etc.

Most of the mechanical wood pulp mills and the chemical wood pulp mills have carried out considerable modernization to utilize capacity to the full and, at the same time, maintain the demand for the very best qualities.

The paper and board industry has also been modernized. No new paper mills have been erected, but seven new paper machines have been installed.

There has been a real increase in capacity which at present is some 20% over the pre-war level, but while carrying out this modernization program stress has been laid on the attainment of a high standard of quality.

In Norway today, there are 45 mechanical wood pulp mills in operation, 16 sulphite mills, six sulphate mills and 51 mills producing paper and boards. Some of these concerns have combined operations producing mechanical wood pulp, chemical wood pulp and paper.

The pulp and paper industry furnishes direct employment for some 20,000 workers and staff, and indirectly provides employment for a similar number of forest workers, men engaged in floating, etc. The industry is also one of the largest consumers of electrical energy, and one of the most important customers of the railways. The export of the pulp and paper products is also a very important factor in shipping circles.

In 1954 production surpassed the level of the best pre-war years, and for certain products it was considerably superior.

In 1954 the mechanical wood pulp industry's production of 644,000 tons air-dry was a record. Compared with the previous year, the production increase was well over 24%. Exports also showed a large increase, reaching 385,600 tons, compared with 308,000 tons in 1953.

Mechanical wood pulp was exported chiefly to the traditional European markets. The United Kingdom, France, Netherlands, Denmark, and West Germany together took 95%. The United Kingdom was the outstanding importer on the market and in 1954 imported 73% of the total exports, followed by France with 10%.

The chemical wood pulp industry also enjoyed a record year in 1954. Production amounted to 590,000 tons, against 544,000 tons in 1953. Output in 1954 was about 7% higher than the former record year of 1937.

The increased production was confined entirely to sulphite. Sulphate production was similar to that of the previous year, but that was due primarily to a prolonged strike of five months' duration at one of the sulphate mills.

Despite the high level of production, however, there was a drop in exports, which amounted to 288,200 tons, compared with 301,000 tons in 1953 and 355,000 tons in 1937.

But this recession must be viewed in the light of increased domestic demands and the conversion of dissolving pulp to artificial silk and staple fibers.

Most of the chemical wood pulp exports went to European markets. The United Kingdom took 44% while 13% went to France, 10% to West Germany, and a little more than 9% to the Netherlands. Belgium and the United States each took 4%.

In the paper and board industry, production in 1954 was 569,000 tons, compared with 505,000 tons in 1953 and 465,000 tons in 1937.

The reason that the export figures have not followed the same increase as the production figures is due to the greatly increased demands of the domestic market. In the last pre-war years the annual consumption was scarely 100,000 tons, whereas, in 1953, this amounted to 190,000 tons and increased further in 1954 to the impressive figure of 212,000 tons, representing a per capita consumption of 62 kilos.

Exports of paper and board reach all the corners of the earth but close connection with the United Kingdom is a dominant feature. In 1954 this largest single outlet was, as in previous years, the largest importer with a total of 19%, followed by Denmark and Australia with 7% each, the Netherlands with 6%, and Belgium, West Germany, Brazil, and India each with 5%.

Of the paper and board exports, 135,000 tons were newsprint, 97,000 tons writing and printing paper, 16,000 tons kraft paper, 21,000 tons sulphite paper, 26,000 tons greaseproof and glassine paper and 40,000 tons boards. There was also a considerable export of cap, tissues, and various other qualities.

The export value of pulp and paper industry products is a dominant factor in Norwegian export statistics, representing over 1 milliard Crowns in 1954, of which mechanical wood pulp represented 190 million, chemical wood pulp about 325 million, paper and board about 455 million and staple fibers well over 50 million Crowns.

Considerable efforts are made to preserve the pulp and paper industry's ability to earn the necessary currency for the national economy. The raw material basis is relatively limited and in the first years there were not many possibilities of extending the mechanical and the chemical wood pulp production on the basis of the ordinary Norwegian raw material.

A certain surplus has now been secured by the importations of pulpwood and to this must be added the results of better utilization of sawmill waste, usage of small-dimensional timber, etc.

Through the intermediary of the Forestry and Forest Industries' Research Organization millions are spent annually in research work, ranging from the tree in the forest to the completed product ready for the market.

Norway is a small country and as a factor in the world's pulp and paper products industries it does not play a decisive role. However, its exports mean very much, not only to Norway's own economy, but also to those concerned with pulp and paper throughout the world.

**Production of Pulp and Paper**
(In short tons, air-dry)

| | *1937* | *1952* | *1953* | *1954* |
|---|---|---|---|---|
| Mechanical wood pulp | 598,959 | 567,426 | 583,711 | 709,698 |
| Sulphite | 527,522 | 454,009 | 503,518 | 555,814 |
| Sulphate | 81,437 | 92,332 | 96,172 | 94,771 |
| Paper | 456,887 | 466,078 | 510,056 | 565,551 |
| Board[a] | 55,702 | 48,654 | 46,983 | 61,445 |

[a] Excluding fiberboards.

**Export of Pulp and Paper**
(In short tons, air-dry)

| | *1937* | *1952* | *1953* | *1954* |
|---|---|---|---|---|
| Mechanical wood pulp | 353,926 | 352,007 | 339,454 | 425,015 |
| Sulphite | 361,973 | 219,638 | 313,929 | 296,409 |
| Sulphate | 29,497 | 15,944 | 18,554 | 21,219 |
| Paper and board | 386,039 | 287,388 | 340,057 | 392,954 |

### Manitoba

Authorities are encouraging construction of a moderate-sized paper mill—either a sulphate or groundwood mill or possibly a newsprint mill at Grand Rapids at the northwestern tip of Lake Winnipeg in Manitoba.

This is the point where the Saskatchewan River empties into Lake Winnipeg. The river drops 101 feet in a distance of 9 miles and it is estimated that a large block of power could be generated at a cost which would present a favorable rate for prime power.

The province of Manitoba intends to develop power at Grand Rapids before 1959 which will permit it to supply a paper mill at this site at a rate in the neighborhood of $25 per horsepower-year for prime power. Power at this rate would be a large factor in the production of low cost paper for several reasons, one of them, it is argued, being the fact that a new mill would not be burdened with capital costs for its own generating equipment.

Recent forest inventory surveys indicate that sufficient wood is economically available which could be delivered to a mill at Grand Rapids by river logging as well as by rail and lake transportation. The Province of Manitoba is said to be disposed to give favorable terms and prices for timber berths.

It is estimated that present wood costs from areas west of Lake Winnipeg in which Grand Rapids is located will run about $18 per cord which is described here as "considerably lower than costs in Eastern Canada and Northern United States mills."

### Improved Glass-Fiber Paper

Research at the National Bureau of Standards has succeeded in producing an all-glass paper eight times as strong as that first made in 1951.‡ Because of its greater strength, this paper should prove much more convenient for those uses—such as gas masks, chemical filters, and electrical equipment§—where the unique properties of the all-glass paper have already made it particularly valuable.

The higher strength is achieved by control of the acidity and temperature of the glass fiber suspension and by minor changes in the mechanical handling of the fibers in the paper mill. Details of the improved process‖ were worked out in the Bureau's paper laboratory as part of a project sponsored by the Naval Research Laboratory.

Although glass fibers have been widely used for some time in textiles, such as glass curtains and filter cloths, and in plastic laminates, their use in making all-glass papers is relatively new. About three years ago, the Bureau, in cooperation with NRL, produced the first machine-made paper composed entirely of glass fibers without additives or binders. This paper, which resembles soft blotting paper, was found to have a number of important applications. Tests showed it to be many times more effective as an air filter than commercial filters then on the market. In gas-mask tests in a smoke-filled room, only one smoke particle in 100,000 passed through the glass-paper filter. Another important advantage of all-glass paper is its high resistance to heat, moisture, chemicals, and microorganisms. This, in combination with excellent electrical characteristics, makes it valuable as an insulator and dielectric for special applications.

Several paper mills are now producing the all-glass paper for military and civilian uses. The product has appeared on the market in mine respirators and gas masks and as filter disks for laboratory crucibles. It is being studied for possible use as a filter of hot or corrosive fluids, as an air filter in air conditioners, as a saturating or laminating base for plastics, and as an electrical insulator in coil windings, condenser and transformer cores, and battery separators. Other possible applications include heat insulation where a thin material is required, sterilizable papers for medicine and surgery, and antitarnish and anticorrosion papers.

However, for all these uses, the low tensile strength of the all-glass paper—originally 30 to 40 p.s.i.—has been a disadvantage, requiring extra care in production, storage, and handling. The improvements made in the process by NBS increase the tensile strength to more than 300 p.s.i. and should thus make the glass-fiber paper considerably more practical for commercial manufacture and use.

Because the properties of glass fibers are so different from those of the cellulose fibers ordinarily used in papermaking, considerable change has been necessary in applying the usual papermaking techniques to the manufacture of glass-fiber paper. For example, in the manufacture of ordinary paper, vegetable fibers are processed with water in a "beater," which bruises the fibers and forms minute fibrillae. Mechanical entanglement of these fibrillae aids in bonding the fibers together. In addition, prolonged beating is thought to increase the adsorption of water on the fibers, which enhances fiber-to-fiber bonding when the fibers of the paper are dried in close contact.

With glass fibers, on the other hand, no fibrillation takes place, and no significant hydration ordinarily occurs. Because bruising breaks the fibers and tends to weaken the paper, the beater is adjusted to eliminate most of the pressure on the fibers and is used merely for suspension and circulation of the fibers.

In the glass papermaking process as improved at the Bureau beating is conducted at a temperature of 85°F., and the pH of the glass-water mixture is adjusted to 3.5 or less by adding sulphuric acid. Under these conditions, the fiber bundles open up and are dispersed more quickly, less fiber breakage occurs, and the resultant paper is stronger.

Mechanical changes have been made in the equipment to eliminate strings or lumps in the finished paper. Because glass fibers in the stock flow system of a paper mill tend to accumulate on any projection or rough place, sharp angles

‡ See "Paper from Glass Fibers," *NBS Technical News Bulletin* 35: 177 (Dec., 1951).

§ See "The Electrical Properties of Glass-fiber Paper," by T. D. Gallinan, R. T. Lucas, and R. C. Bowers, *Elect. Mfg.* 48: 94 (Aug., 1951).

‖ For further technical details, see "Effects of Mechanical Preparation and pH on the Strength of Glass-fiber Paper," by Martin J. O'Leary, Robert B. Hobbs, J. K. Missimer, and James J. Erving, *Tappi* 37: 446 (1954).

Table I. Effect of Evaporation at Room Temperature of Liquids from Fibrous Materials[a]

| Experiment | Fibrous material | Liquid | Atmosphere | Time when fluorescence was observed |
|---|---|---|---|---|
| 1 | Cotton, light excluded | Benzene | Oxygen | Within 16 hr. |
| 2 | Cotton, light excluded | Xylene | Oxygen | Within 16 hr. |
| 3 | Cotton, light excluded | Chloroform | Oxygen | Within 12 hr. |
| 4 | Cotton | *n*-Pentane | Oxygen | Within 16 hr. |
| 5 | Cotton, entire strip wet, no interface | *n*-Pentane | Oxygen | No fluorescence within 3 days |
| 6 | Cotton, degassed for 8 days | *n*-Pentane | Nitrogen | Within 24 hr. |
| 7 | Cellulose acetate | Water | Oxygen | Within 40 hr. |
| 8 | Nylon | Water | Oxygen | Within 40 hr. |
| 9 | Nylon | *n*-Pentane | Oxygen | Within 24 hr. |
| 10 | Nylon, entire strip wet, no interface | *n*-Pentane | Oxygen | No fluorescence within 3 days |
| 11 | Nylon | *n*-Pentane | Nitrogen | No fluorescence within 3 days |
| 12 | Nylon | *n*-Pentane, shaken with oxygen 12 hr. and then degassed | Nitrogen | No fluorescence within 3 days |
| 13 | Quartz, light excluded | *n*-Pentane | Oxygen | Within 24 hr. |
| 14 | Quartz | *n*-Pentane | Nitrogen | No fluorescence within 3 days |

[a] Unless otherwise indicated, a strip of the fibrous material was suspended in the liquid in such a way that a wet-dry interface was present on the fibrous material. The fluorescence was observed at the interface. Experiments were carried out in the diffuse light of the laboratory except as indicated.

were eliminated from the piping. A horizontal stock chest with agitators moving in a vertical plane was also installed so that the fibers would fall back into the liquid instead of accumulating in strings as they do on horizontal agitators.

When the fiber suspension was brought to a pH of 3.0 as it entered the jordan, it was found possible to pass it through the jordan refiner of the paper mill without damage to the fibers, a step that had hitherto been impossible. Treatment in the jordan also helped to break down strings and knots, resulting in a much improved formation in the finished sheet.

Previously it was necessary to maintain a fairly high moisture content in the all-glass paper in order to carry it onto the reel of the paper mill, for the glass paper has a higher tensile strength when wet than when dry. The additional strength was sufficient to eliminate breakage between the driers and the reel. However, glass papers made by the Bureau's improved process have enough strength that they can be dried to the same extent as cellulose papers and still be carried onto the reel without breaking.

Photomicrographs made at the Bureau show the effect of a lower (more acid) pH in binding the fibers together to give higher strength. Ordinarily acid reacts so slowly with glass as to have negligible effect. However, the very fine glass fibers expose a tremendous surface to the acid, which starts to dissolve the soda and lime in the glass, leaving on its surface a thin gelatinous layer, rich in silica. When the water drains from the fiber suspension on the wire of the papermaking machine and the fibers are pressed together, this gelatinous layer acts as an adhesive to bond the fibers together in the paper. The pH value must be below 4 to obtain this effect, and the tensile strength increases as the pH decreases in the range studied (down to 2.9). Ionizable acid is drained off during the formation of the sheet, so that the pH of the finished paper is effectively neutral—from 7.0 to 7.4.

The use of acid also causes rapid dispersal of the fibers in the beater. This may be due in part to an ionic electrical phenomenon resulting from the initiation of the chemical reaction between the acid and the glass. It is known that negative electrical charges appear on the surface of the glass, and the mutual repulsion of the like-charged surfaces is probably responsible for the quick separation of the fibers.

A temperature of 85°F. in the beater likewise aids in promoting dispersion of the glass fibers. The decreased viscosity and interfacial tension of the heated water apparently causes it to wet and penetrate the fiber bundles more readily.

### Brown-Line Effect on Fibrous Materials

The National Bureau of Standards has extended its previous research on moisture effects in cotton textiles to a more general investigation of the effects of both water and organic liquids on fibrous materials. The boundaries between wet and dry areas on cotton, nylon, acetate, and quartz fibers have been found to be regions of exceptional chemical activity in a study* conducted by R. Schaffer, W. D. Appel, and F. H. Forziati of the Bureau's textile laboratory. Results of this work indicate that either the fibers or the evaporating liquid at the boundary undergo oxidative changes in a few hours or days, even at room temperature. In view of the frequency with which wet-dry interfaces occur during the processing and use of textiles, papers, and other fibrous materials, it appears that the reactions studied by the Bureau may be of wide interest.

When water evaporates from cotton cloth, a brown line is often observed at the boundary between the wet and dry areas. In 1952 the Bureau investigated this effect in a series of experiments† in which one end of a strip of cotton cloth was kept immersed in water in the presence of air at room temperature. A water-soluble brown line which fluoresced in ultraviolet light was formed at the wet-dry interface. When the brown material was extracted from the cloth, it was found that the cloth had been converted to oxycellulose of an acidic, mildly reducing type, with consequent weakening of the material.

In the present investigation, similar experiments were carried out using cotton cloth with benzene, xylene, chloroform, and *n*-pentane; nylon cloth with *n*-pentane and with water; acetate cloth with water; and quartz-fiber paper with *n*-pentane. In each of these experiments, fluorescence followed by browning developed at the boundary between wet and dry areas within a day or so.

To determine the importance of oxygen to the reaction, experiments using nylon cloth and quartz-fiber paper with *n*-pentane were carried out in an atmosphere of nitrogen instead of air. The "brown-line" reaction did not occur. Negative results were also obtained in experiments carried out in air but so arranged that *n*-pentane rose by capillarity to the top of specimens of cotton and nylon cloths. Thus, the presence of oxygen and of contiguous wet and dry areas appears to be essential to the reaction.

The brown-line products from the experiments with cotton and organic liquids, unlike those obtained with cotton and water, are soluble in organic liquids but insoluble in water. That these products are derived from the organic liquids instead of the cellulose is suggested by the failure of the cloth to show the characteristic reactions of oxidized cellulose. As quartz is not subject to oxidation, there can be little doubt that the brown line obtained with quartz-fiber paper and *n*-pentane is derived from the *n*-pentane.

* For further details, see "Reactions at Wet-dry Interfaces on Fibrous Materials," by Robert Schaffer, Wm. D. Appel, and Florence H. Forziati, *J. Research NBS* 54: 103 (1955), RP2570.

† See "Some Observations on the Evaporation of Water from Cellulose," by Herman Bogaty, Kenneth S. Campbell, and William D. Appel, *Textile Research Journal* 22: 75 (1952); "Effect of Moisture and Ozone on Cotton Textiles," *NBS Technical News Bulletin* 36: 92 (June, 1952).

## Noise Abatement

In the summer of 1954 the Technical Section, Canadian Pulp and Paper Association, brought to the attention of the National Research Council, Ottawa, the problem of noise in paper mills. It was hoped that the Council, with the cooperation of a Special Technical Section Committee on Noise Abatement, could reach a solution to this increasingly serious problem.

The National Research Council assigned the problem to the Applied Physics Branch, L. E. Howlett, Director, where G. J. Thiessen, an expert in acoustics, has tackled the problem from three angles as follows:

*(1) Information on Past Work*

Each of the companies represented on the committee has contributed complete information (including confidential data) of past activities in this respect within their companies. In addition, sufficient information was gathered from other laboratories, patent literature, etc., so that a positive approach to the problem could be made.

*(2) Temporary Method for Workers' Protection*

The National Research Council has developed a highly effective, cover-type ear protector in an effort to provide effective protection for the worker, until such time as the lengthy and sustained effort required to silence machinery has been successfully made. The National Research Council made six pairs of "ear muffs" and sent them, three pairs at a time, to six of the paper mills represented on the committee so that they could be tested under mill conditions. The mills ranged from Powell River in the west to Anglo-Newfoundland in the east. Of some fifty people who tested these ear covers, for periods of from one to six shifts,

100% reported that they were highly effective;
92% commented on their excessive weight;
70% commented on the accompanying heat and/or perspiration; (a similar percentage found them bulky);
30% found intelligibility improved;
40% found them acceptable "as is";
48% agreed that they would wear them if the above criticisms were overcome;
only 4% indicated that they would not wear them.

The comments made encouraged the National Research Council to redesign the ear covers to overcome the three outstanding faults. The second design has most of the dangerous protrusions removed, a 40% reduction in weight, cups one half the volume of the first ones, and an improved appearance. It was felt that this weight reduction was as large as is practicable for minimum loss in efficiency. It is hoped to interest a company in producting one hundred pilot models prior to full scale production. The time required for commercial production is not yet known, but limited numbers will be offered to the industry as they become available.

*(3) Silencing of Suction Rolls.*

To reach a tentative solution to the problem of couch noise, a small model of a suction roll was made at the National Research Council for intensive study. Although the model is only 1 ft. in diameter with a 2-in. perforated face, it produces noise comparable in level to a commercial couch and has provided data used for the design of a silencer, giving 15 to 30 db. reduction of noise level on the laboratory model. It is hoped that a silencer, now in the design stage and scheduled to be installed on a 272-in. machine at the Gatineau mill of the Canadian International Paper Co. by the end of May will prove that paper can be made efficiently on a silencer-equipped open machine and that the mill trial will confirm laboratory results, thus eliminating the largest noise source from the machine room.

Another type of silencer, utilizing the same principle but differing in design and applicable only to machines equipped with vacuum transfer has been tested on a conventional machine with the sheet running into the pit, with impressive reductions in noise level. A mill trial of this devise on a high-speed vacuum-transfer-equipped couch at Baie Comeau is presently under consideration.

It is evident that a remarkable contribution has been made to the solution of the problem by the National Research Council, although there are still many outstanding problems which must be overcome before a complete solution is realized. A formal session outling the work to date has been programmed for the 1955 Summer Meeting of the Technical Section in Quebec City beginning June 6. This session will consist of a paper describing work done at Baie Comeau, another describing work done at Powell River, and two papers by Dr. Thiessen, one outlining the development of the National Research Council ear protectors, and a second detailing the principle and the laboratory development of the suction roll silencer. The latter will include, if available, results of the mill trial at Gatineau which, it is hoped, will have been completed by that time.

## Canadian International Paper

Canadian International Paper Co. has completed arrangements for acquisition of all of the outstanding shares of Hygrade Containers Ltd., one of Canada's leading manufacturers of corrugated shipping containers, with a plant at London, Ontario.

The Hygrade Containers plant is a completely up-to-date corrugating plant. The company operates two corrugating machines and employs about 300 men and women. Operations are carried on in a single building of approximately 160,000 sq. ft. of floor space. Hygrade Containers, with its present staff, will operate as a subsidiary of Canadian International.

Canadian International also plans construction of a shipping container plant at Pointe-aux-Trembles near Montreal, Quebec. This plant, when it is completed late in 1955, will be operated by Hygrade Containers.

***Pulp and paper production starts this Summer at the Murupara project of the Tasman Pulp & Paper Co. Ltd. in New Zealand. The huge plant will produce 35,000 tons annually from the man made forests in New Zealand's north island. The whole project, including the town site in the background, cost $75,000,000. Sandwell & Co., Ltd., Vancouver, Canada, are consulting engineers while construction is being handled jointly by Merritt-Chapman and Scott Overseas Inc., New York; Raymond Concrete Pile Co. of Delaware, New York; and Fletcher Construction Co. of Auckland, New Zealand***

Shortly after Canadian International purchased the kraft pulp mill at La Tuque, Que., in the Fall of 1954, it announced expansion of that mill and plans for installation there of a large kraft paper and container board machine. The container plant at London and the other plant to be built near Montreal will absorb part of the output of the new machine in La Tuque.

Although Canadian International has been active in some fields of paper conversion through another subsidiary, Continental Paper Products Ltd., of Ottawa, the company has never previously been engaged in the production of corrugated shipping containers.

Other major products of Canadian International and its subsidiaries are newsprint, dissolving pulp for use in the manufacture of rayon and other cellulose-based synthetics, high grade bleached paper pulps, plywood, hardboard, and lumber. Among by-products from waste liquors resulting from chemical pulping processes are ethyl alcohol, antifreezes, turpentine, shellac, and industrial insulation materials.

### Valentine

The only plant in the United States using whole sugar cane bagasse for paper manufacture is being expanded from its present capacity of 50 tons of paper daily to 75 tons.

The plant is that of Valentine Pulp & Paper Co., located seven miles south of Lockport, La., on storied Bayou Lafourche, in the heart of Louisiana's sugar bowl. It is owned jointly by Brown & Root, Inc., Houston, Tex., and the Valite Corp. of New Orleans. The $5,000,000 plant was designed and constructed by Brown & Root.

Bagasse is the dry stalk of sugar cane after the juice has been extracted in the sugar mill. Heretofore it has been a waste and a nuisance, although some has been used for boiler fuel and for the manufacture of wallboard. Great stacks of it in bales are visible around most Louisiana sugar mills. It is estimated Louisiana produces 800,000 tons of dry bagasse annually, less than 40% of which is used. Progress of the Valentine plant has been closely watched by the sugar industry of the world.

The Valentine process, which is patented wherever cane is grown, will provide a new market for a material which heretofore was hardly worth the expense of baling. The mills were faced, however, with the necessity of baling or burning the residue to get it out of the way. Especially interested in the process are those countries which produce cane but have to import all their paper.

The Valentine mill uses all of the cane, including the pith which in all processes heretofore had to be removed by an expensive depithing process.

The plant is now producing mostly letterpress and offset printing stock, white tablet, and envelope paper. Some grades have been used in multiple business forms and a few special runs have been released for newsprint, used in some 25 Louisiana papers near here. Experimental runs have produced creped and glazed tissues of excellent quality; machine finish book; napkins and place mat papers; and heavier grades suitable for food packaging. Papers already sold have proved entirely satisfactory for printing, writing, waxing, or coating as required.

As in all plants, a large amount of water is required and the Lockport plant pumps 60,000 gal. from Bayou Lafourche for every ton of paper produced.

The Lockport plant is located adjacent to the Valentine Sugars, Inc. sugar mill, insuring a year-round supply of bagasse. The paper plant employs some 100 workers, mostly from the immediate area, on a 12-month basis, spreading out employment in an area accustomed to sugar mill work only in the short harvest season.

### Empire-Coates

Empire Box Corp. has changed its name as follows: in Gairfield, N. J., the new name is Coates Board & Carton Co., Inc.; and in Stroudsburg, Pa., the new name is Coates Board & Carton Co., Inc. of Stroudsburg.

### Brown

Brown Co., Berlin, N. H., plans to spend about $16 million in plant improvements over the next three years. The new equipment will include a 220,000 lb./hr. boiler, a new sulphate bleach plant, pulp screening and cleaning equipment, indirect heating equipment for sulphite digesters, and chip handling equipment.

### Gair

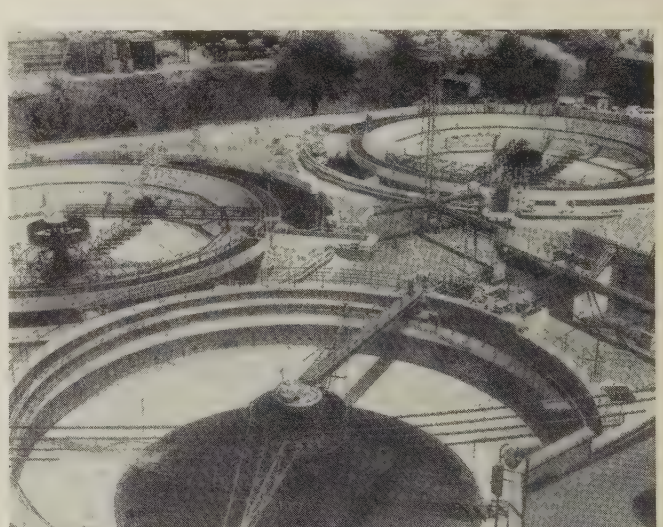
Robert Gair Co. has installed two new vats on the no. 1 machine at its Havermill, Mass., mill, giving the machine a total of nine vats equipped with an air exhaust system for removal of air from the interior of the 42-in. cylinders.

### Rhinelander-Weyerhaeuser

The R-W Paper Co., jointly owned by Rhinelander Paper Co. and Weyerhaeuser Timber Co., has started construction of its glassine and greaseproof mill at Longview, Wash. The mill, with an annual capacity of 10,000 tons, will have the largest machine for these grades in the country and will come into production in the Summer of 1956.

### West Virginia

West Virginia Pulp and Paper Co.'s new $2 million waste treatment plant at Covington, Va., is ready for operation.



***Shown in final stages of construction, this new 2 million dollar waste treatment plant at the Covington, Va., mill of West Virginia Pulp & Paper Co. is now completed and ready for initial operation***

The plant will use the activated sludge process to reduce the BOD of the mill effluent 80–90% before discharging it into the Jackson River. Pulping wastes, after settling in a 100-ft. Dorr Clarifier will be combined with clear bleach wastes and the mixture aerated and settled in two 175-ft. Currie Clar-aetors.

### St. Regis

St. Regis Paper Co. is carrying out a $10 million expansion program at its Jacksonville, Fla., and Tacoma, Wash., mills. The new paper machine at Jacksonville will have a capacity of 1000 tons of linerboard daily and a speed of 2500 f.p.m. The new machine at Tacoma will have a capacity of 400 tons

of kraft paper daily, which will almost double St. Regis kraft production capacity.

H. Dyer Phillips has been appointed resident woodlands manager at the Deferiet, N. Y., mill of St. Regis.

### Rayonier

Rayonier, Inc. recently entertained about 10,000 people in two groups at its new Florida tree nursery. The purpose of the gatherings was to publicize the company's conservation policies and to call for a more dynamic approach to public conservation measures, which the company considers outdated. The gathering was addressed by Sen. Warren G. Magnuson who criticized the federal and state policies which do not permit conservation programs such as Rayonier's, but which allow millions of board feet of prime commercial timber each year to mature, die, topple over, and rot, without even providing minimum facilities so that fallen timber could be dragged out and made available.

### Riegel

Riegel Carolina Corp., Acme, N. C., set a new record in April, when the daily average production for the month was 340 tons.

### Simpson

Simpson Logging Co. is studying the behavior of barked Douglas-fir logs when stored in salt water for a period of several months. If results are favorable, Simpson may install whole-log barkers at its Shelton, Wash., sawmills.

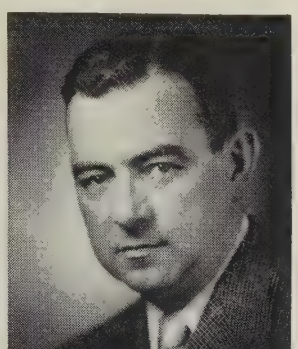
### Powell River

Powell River Co., Powell River, B. C., have announced plans for the installation of a ninth newsprint machine and auxiliary equipment, at a cost of about $20 million.

### Hammermill

Fred E. Bahrenberg has been appointed general superintendent and Robert S. Young superintendent of manufacturing of the Hammermill Paper Co., Erie, Pa.

*F. E. Bahrenberg, Hammermill Paper Co.*



*R. S. Young, Hammermill Paper Co.*

### Falls Paper and Power

Stream conditions in the Oconto River should be substantially bettered by a project now under way at Falls Paper and Power Co. with approval of the state Committee on Water Pollution. An 8-acre semicircular storage lagoon will be teamed with the company's roadbinder program.

The company has assured the state that the mill will withhold at least 60% of its total sulphite solids during the critical months of low water flow and high temperatures. Periodic technical surveys will be conducted to guide lagoon operation and evaluate results. Under particular observation will be the water of the Stiles pond. Since construction of this dam several miles below the mill in 1948, bacterial action on submerged organic material, as well as sulphite solids have produced unsatisfactory conditions.

The new lagoon is designed to hold 18,000,000 gal., equal to six months' output of collectible full strength, spent sulphite liquor from the Falls mill. Last year the mill diverted to roadbinder use more than 7,500,000 gal. of liquor that otherwise would have flowed into the stream.

In its new lagoon the company will store and thus withhold from the river all full-strength liquor produced during hot, dry weather beyond what goes into roads or into pollution-abatement experiments. Liquor produced during weekends will also be stored and thus available for use on highways. Last summer's roadbinder demand sometimes outran weekday output.

Unlike several Wisconsin installations where sulphite mills filter spent liquor through soil layers to reduce its oxygen demand, the Falls pond is being made watertight by lining the bottom and the surrounding dikes with compacted clay. When autumn's cool weather and rains boost the river's capacity to handle the material, liquor will be discharged in even flows at such rates as should maintain the stream in satisfactory shape. Later when winter cold and spring runoffs give the river its maximum capacity to handle liquor, the discharge rate will be stepped up to take all output from the mill and empty the lagoon as fast as river conditions will permit.

Situated on the river bank below the pulp mill, the lagoon will be fed by a 4-in. plastic pipeline 500 ft. long, with appropriate valves, pumps, and other mechanical equipment.

### Weyerhaeuser

Boom men at Weyerhaeuser Timber Co.'s Everett, Wash., lumber division are no happier about falling in their Snohomish River log pond than they ever were, but feel a lot more confident about floating than they did a month or so ago.

During wet, windy weather the men who jockey the big sticks around the pond wear bright yellow rain coats and pants with built-in life preservers. Inside each jacket are 28 air tubes and lining the pants are two king-size tubes. The combination makes it literally impossible for a man to sink, no matter how big his shoes or how heavy his clothing.

By buying regular rain jackets and pants, and having a local firm make the life-saving lining to specifications, the company has come up with what seems to be the best answer yet to the potential danger of working on the pond.

### Kimberly-Clark

Another major step in stream improvement of the Fox River is planned by the Kimberly-Clark Corp., Neenah, Wis. Hereafter, the goal of its Kimberly mill will be to reduce still further the discharge of spent sulphite liquor, so that the mill will discharge only half as much in proportion to the stream flow as has been its practice since the other major reduction was started in 1950.

For the past five years, this mill has utilized or otherwise withheld from the stream enough of its liquor to abate water pollution by at least 40%. Disposal facilities newly completed are now designed to increase this abatement to 70%.

In part, this new goal has been made possible by a continuing program of technical experimentation and study carried on in recent years. Kimberly-Clark is now using a large acreage of geologically suitable impervious clay soil within pumping or hauling distance of the mill. Research has demonstrated that when spent sulphite liquor is stored on this soil, very little liquor seeps into the ground.

Taking advantage of this soil condition, Kimberly-Clark last fall started to rebuild its spent liquor holding ponds as

well as its piping and pumping installations. Storage capacity of its reconstructed ponds is 20,000,000 gal. These changes will allow the ponding of additional amounts of liquor, making possible the further reduction of flow into the river.

As part of its experimental program, the mill has hauled spent liquor to at least five different disposal pits during the past 5 years. One area had to be abandoned because liquor drained too quickly into the soil. Others proved impracticable because distances from the mill were too great. The new facilities overcome these obstacles.

The rebuilt system of holding ponds is teamed with Kimberly-Clark's large-scale roadbinder program, which utilizes spent sulphite liquor for improving unpaved roads. During the roadwork season, demand for roadbinder beyond current production is met by pumping stored liquor into roadbinder spreader trucks. Expectations are that this will keep the ponds below their storage capacity at all times. If emergency low stream flow and high temperatures should excessively increase stored quantities, pond levels can be controlled by release of some liquor to the river during spring freshets, without harmful results.

### Lowe

Donald V. Lowe, president of the Lowe Paper Co., Ridgefield, N. J., has been elected chairman of the Port of New York Authority.

### Crown Zellerbach

Crown Zellerbach Corp. plans the construction of a 22-floor multimillion dollar headquarters office building in downtown San Francisco at the junction of Market, Bush, and Battery streets. The paper manufacturing corporation's new headquarters is expected to be completed in mid-1958.

The new office building is expected to be one of the most attractive and functional on the Pacific coast. It will cover a rectangular area of 13,000 sq. ft., and will be surrounded by 20,000 sq. ft. of landscaped gardens. An underground two-level garage will hold more than 200 cars.

The building will be completely fireproofed and air-conditioned. Its 230,000 square feet of office space will be on completely open floors, free of columns or other obstructions, with broad vistas of glass to provide a light and airy outlook. The open floor space is designed for maximum adaptability through the use of movable partitions. All building services, including automatic elevators, will be housed in an adjoining tower.

### Bowaters

Sir Eric Bowater, Chairman of the Bowater Paper Corp. has revealed further details of the plans for expansion of the Bowaters Southern Paper Corp. mills at Calhoun, Tenn. The U. S. operations, which mark the entry of the worldwide Bowater's organization into the U. S. newsprint manufacturing field, are now producing newsprint and kraft pulp at the annual rate of 160,000 tons and 65,000 tons respectively.

The major expansion program, as outlined by Sir Eric at the annual shareholders' meeting on May 25, will involve an expenditure of some $25,000,000. The program will be completed in the Fall of 1956. In 1957, it is anticipated that the output of Bowaters Southern Paper Corp. mills will have risen to some 270,000 tons of newsprint per annum.

Because of the complexity of the program, it will be undertaken in three parts. Phase 1, authorized in January of this year, is now in progress and will be completed in early October, 1955. This part of the program is aimed at increasing the production of present equipment by removing certain bottlenecks in the operation. The additions and changes to be instituted during this period will further increase the mill's newsprint production rate.

During this first phase of expansion, the sulphate mill will be enlarged by the addition of a fourth stage brown stock washer, to be supplied by Improved Machinery Co., Inc., Nashua, N. H., and by additions to the bleaching and storage facilities. These improvements are expected to increase the efficiency of the sulphate mill to a point where the second part of the expansion program will be made possible with a minimum of future additions and changes.

In the groundwood mill, additional thickening equipment and stock chests will increase the capacity of the present system. The mill now has six groundwood vacuum thickeners in operation.

Contracts for the tile work to be done in the groundwood mill and the woodyard during this first phase of expansion have been let to the Stebbins Engineering and Manufacturing Co., Watertown, N. Y.

The second part of the company's Tennessee expansion program will involve virtually every department in the Calhoun mill from wood handling to shipping. In general, this second phase of expansion will consist of a third newsprint machine, 276 in. wide and capable of operating in the speed range of 2000 to 2500 f.p.m. This machine will be manufactured to Bowaters' specifications by the Beloit Iron Works, Beloit, Wis. The additions and alterations to be instituted in the sulphate mill during phase 1 will enable the mill to supply sufficient chemical pulp furnish for the new machine, but it will be necessary to add six additional grinders to the groundwood mill. Finishing, shipping, and storage facilities will also be increased to handle the greater volume of newsprint.

Overall, it will be necessary to provide 6,000,000 cu. ft. of building volume in the mill and 1,000,000 cu. ft. in the power house.

In the wood preparation department, one additional rotary barking drum will be installed, together with the conveyors and other equipment necessary to adapt it to the present system. The mill now has three chain-suspended barking drums.

One additional digester, to be supplied by Wyatt Metal and Boiler Works of Dallas, Tex., will be added to the sulphate mill's present bank of five digesters. The new digester will be of stainless steel construction in contrast to the digesters now in operation, which are made of carbon steel. The cladding will be of 316ELC stainless steel.

***Bowaters Southern Paper Corp., Calhoun, Tenn.***

Six Waterous Great Northern improved grinders, each capable of producing 50 tons of groundwood pulp per day, will enlarge the groundwood mill to 14 grinders. The grinders scheduled for installation are unique in that each will be powered by a 6000-hp. synchronous motor. It is believed that these will be the largest electrical motors ever used to

drive individual grinders. They will be furnished by Electrical Machinery Manufacturing Co. of Minneapolis, Minn. Additional thickening and storage facilities will complete the program in the groundwood mill, but space will be provided in the new building for two more grinders at a future date.

The focal point of Bowaters' expansion program will be the 276-in. newsprint machine. This machine will be similar to the two now in operation, but will incorporate new features developed in part by Bowaters' personnel. The no. 1 newsprint machine at the Calhoun plant has the distinction of having recently run, over an extended period, at 2118 f.p.m., the fastest speed yet attained by a newsprint machine. It is expected that Bowaters' new machine will normally operate at a speed well in excess of 2000 f.p.m.

The winder, also to be supplied by Beloit Iron Works, will be a heavy-duty, double-drum type, designed to operate at a maximum speed of 6000 f.p.m.

The drive for the paper machine will be a General Electric multiple-generator, electronic-amplidyne controlled, sectional type. Three main motor generator sets will provide power to drive each section with a d.c. electronically regulated motor.

Existing conveyors in the shipping and storage areas will be extended into the new building, and another freight elevator will also be installed. In order to handle the increased volume of newsprint and pulp shipments, the rail loading shed will be extended.

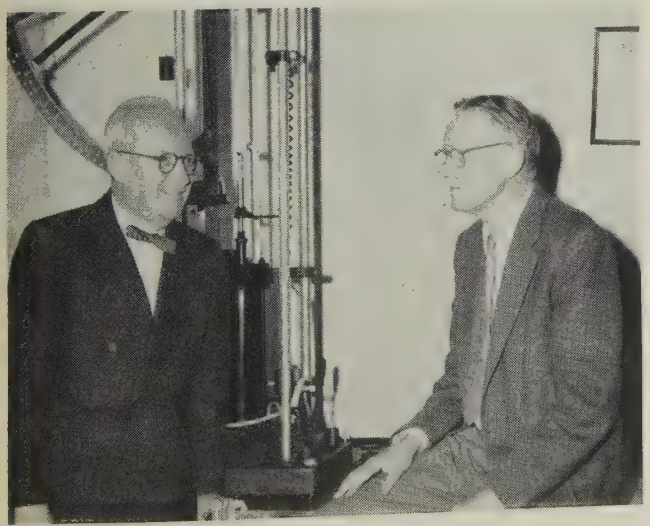
The present electrical demand of the Calhoun mills is 45,000 kw. When the new paper machine, grinders, and other equipment go into operation, the power demand will be increased to 80,000 kw. The Tennessee Valley Authority substation, located at the plant site, will supply 10,000 kw. of the additional demand, while a condensing automatic extraction turbine-generator with accompanying gas-fired power boiler will provide the balance of 25,000 kw. The generator and power boiler will be located in an extension to be built onto the present power house.

The new boiler, to be furnished by Babcock & Wilcox Boiler Division, will supply approximately 350,000 lb. of steam per hr. at 850 p.s.i.g. and 900° F.T.T. It will be equipped for either gas or oil firing, with provisions for firing with pulverized coal as a possible future alternate fuel.

The third part of the Bowaters' expansion program, which is to follow, will involve the installation of equipment to provide pulp to be produced from local hardwoods.

### University of Alabama

Egypt has no trees for wood pulp, yet she now produces 50 to 60% of her own paper.



*K. H. Lauer and R. D. Brown, University of Alabama*

Karl H. Lauer, new member of the department of pulp and paper technology at the University of Alabama is in part responsible for helping the country overcome its paper problem.

As director of the Institute of Applied Chemistry in Alexandria after World War II, Lauer and other chemists found that rice straw, which is abundant in Egypt, could be successfully substituted for wood pulp in production of many types of paper. More recently, he aided the Brazilian government as a UNESCO expert on cellulose research and industrial planning. Under his direction, successful experiments were made in using mixed tropical woods for pulp in papermaking.

Lauer, a native of Austria, studied at the University of Vienna, and won his Ph.D., with honors, from the Technical University in Prague, Czechoslovakia.

### Safety Congress

The 43rd National Safety Congress and Exposition will be held October 17–21, 1955 in Chicago, Ill. Complete information is available from R. L. Forney, general secretary, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

### Furniture Supply Fair

The newest cost-cutting paper products, ranging from fiber to packaging material, will be shown at the National Association of Furniture Manufacturers Supply, Equipment, and Fabric Fair, to be held in Chicago, Aug. 28–Sept. 1, 1955.

### Packaging and Materials Handling Show

The Society of Industrial Packaging and Materials Handling Engineers will present its annual Packaging & Handling Exposition at Kingsbridge Armory, New York, N. Y., Sept. 20–22, 1955.

### Fleck

Rupert Ross has joined The Alexander Fleck Ltd., 416 Wellington St., Ottawa, Canada, as a sales engineer. Fleck is associated with E. D. Jones & Sons Co., Sveen-Pedersen Sales Corp., and other equipment firms.

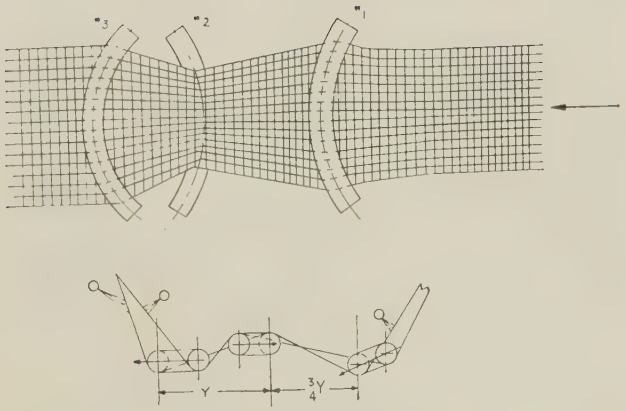
### Mount Hope Felt Preserver

Keeping paper machine felts clean had been a rather substantial problem at Eastern Corp.'s installation in Lincoln, Me. Because Eastern was able to solve this almost universal problem with appreciable economic and practical values, the experience detailed in this article will be of interest to other paper mill operators who have long faced a similar problem.

The development of the equipment installed by Eastern was a logical outgrowth of Mt. Hope's long experience with the so-called "free-wheeling" expander, widely used in the textile industry for spreading and eliminating wrinkles in

*D. J. Robertson, Mount Hope Machinery Co.*

*Rupert Ross, The Alexander Fleck Ltd.*




***How the Mount Hope felt preserver works: no. 1 expander spreads felt and opens weave; no. 2 expander squeezes weave together gently; no. 3 expander spreads weave open to maximum width. Showers placed immediately after expander no. 3 wash out fiber and stock dislodged from felt by above "working" action***

fabrics, from fine silks to carpeting. The expander is a ball-bearing mounted, rubber roll rotating on a curved axle bowed to give even, smooth widthwise spreading to fabrics and any other stretchable material.

Several years ago, engineers at Mt. Hope decided that application of this free-wheeling expander idea had logical applications in fields outside of the textile industry which used similar machinery. Specifically, they became interested in the papermaking and plastics industries.

Eventually these men became intrigued to find that in this day of automatic washing machines, industry was still using the old-fashioned method of literally beating out dirt, stock and other foreign matter from papermaking felts. It seemed that a better cleaning job could be done on the felt with a scrubbing action like any piece of fabric that has been embedded with dirt. Following this line of reasoning, it was concluded that an efficient cleaning operation could be accomplished by working the felt in and out widthwise, thus eliminating the use of whippers and similar equipment and their abrasive action on the felts.

In time, the Mt. Hope Machinery Co. designed a unit consisting of three free-wheeling expanders, coupled with a system of penetrating showers. The three expanders were set in a row with the first spreading the felt to full width; the second shrinking it down as narrow as possible without wrinkling; and the third again spreading it out to the required width. This gentle "out-and-in-and-out-again" action actually dislodges the stock and dirt embedded in the felt. Also, by turning one or more of the rolls into the felt as required, it comes off the last expander stretched to full width with a straight seam. The weave is then square and open and the stock is loose.

Along with this system of rolls, the carefully designed series of showers actually removes embedded foreign matter. The first shower is directed against the side of the felt which is away from the paper, and is used to remove the dirt which has been loosened by the repeated stretching and compressing of the felts through the unit, plus further loosening of particles embedded deep within the pores. This is then removed by the no. 2 shower. The penetration of this shower is directed toward the side of the felt which was next to the paper. So much for the operating principles of the felt preserver.

Two installations of the felt preserver were made at Eastern Corp.'s Lincoln, Me., mill in 1954. The units were installed on the first felts of two separate Rogers wet lap machines (single vat). These installations can best be described in terms of the results that have been achieved to date. Specifically, the following points have been noted:

(1) *Increased Felt Life.* Before installation of the felt preserver approximately 26 felts per year were used to meet normal production schedules. With the felt preserver, the company is currently using 15 felts per machine. But perhaps more meaningful are the figures detailing the cost of the felt per ton of wet lap pulp produced. With the use of whippers for cleaning the felts, the average cost per ton of wet lap produced was $1.04. With the felt preserver, the cost of of the felt has been slashed to 53¢ per ton of wet lap pulp produced.

(2) *Higher Felt Cleaning Efficiency.* It has been determined that the felts themselves are more thoroughly cleaned with the felt preserver then they were when whippers were used.

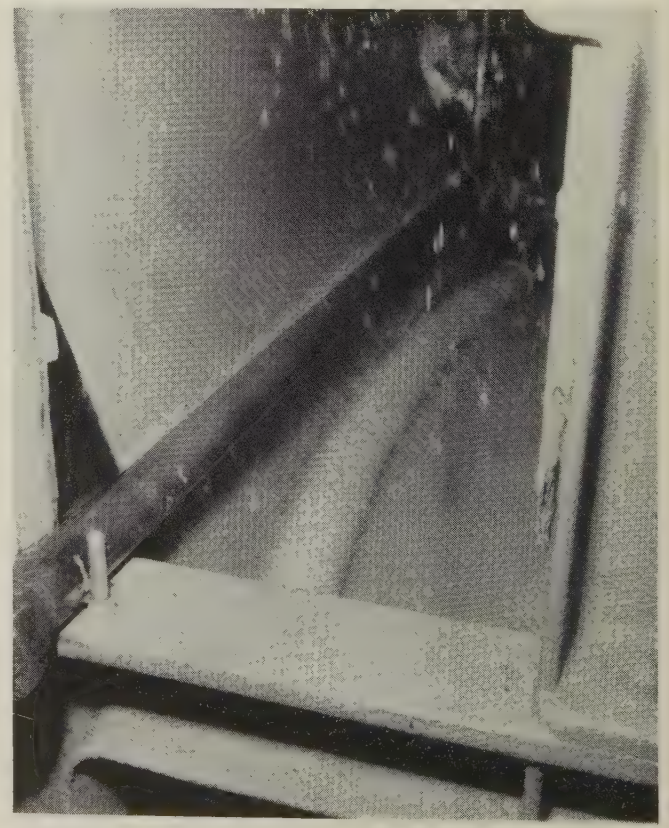
(3) *Less Down-Time.* Plant operating personnel estimate that by eliminating the excessive vibration set up when whippers were used, down time on the machines has been drastically cut. Before the installation of the Mt. Hope felt preserver, the cost of unscheduled repairs was 40¢ or better per ton of wet lap produced. Since the installation of this equipment the cost is currently about 25¢ per ton.

(4) *More Favorable Operating Conditions.* Plant personnel at Eastern report that the excessive noise and vibration which were present when whippers were used have been eliminated.

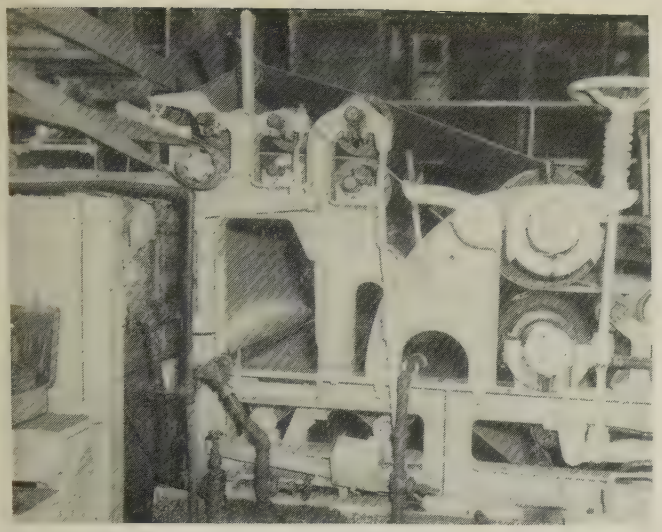
(5) *Savings in Original Felt Cost.* Without the whippers, reduced lengthwise tension coupled with stretching action allows the use of narrower felts. In this case, the felt has been reduced from an original 74 inches to 68 inches. This in itself means a significant annual savings in felt cost.

(6) *No Change in Moisture Content of Air-Dried Pulp.* This figure ran 38 to 40% when a whipper was used. There has been no change since the installation of the felt preserver.

(7) *Felts Retain Original Condition Longer.* With the use of the felt preserver the felts themselves remain open and



***View indicating the action of the powerful showers in conjunction with the Mount Hope free-wheeling expander***



*Portion of the Rogers single-vat wet machine containing Mount Hope felt preserver (seen at left). The operation of one of the two showers can be seen through the opening at the center left. Note that the felt preserver requires little space, is easily installed*

soft, maintaining their initial efficiency throughout most of their entire life.

### Crucible

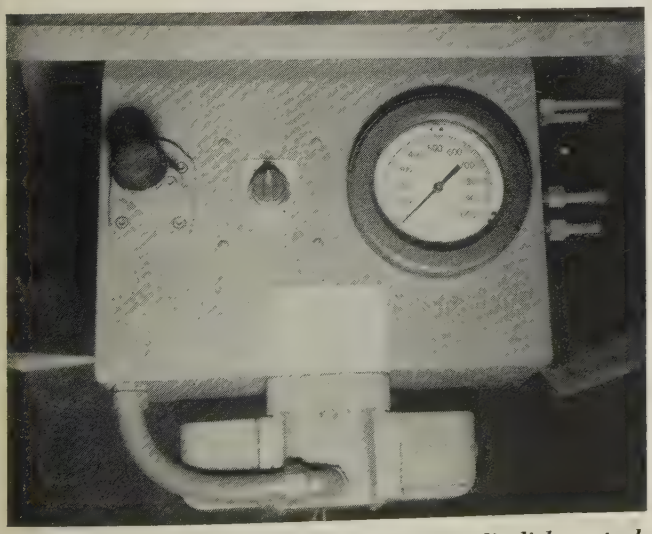
The Crucible Steel Co. of America, P.O. Box 88, Pittsburgh, Pa., has published a booklet entitled "Crucible Accument Precision Investment Castings" describing special techniques outlining the relatively new "lost wax" method of precision casting.

### Testing Machines

Testing Machines Inc., 123 W. 64th St., New York, N. Y., is offering a new gearless micrometer known as the Model 555.

### Sutherland

The Sutherland Refiner Corp., Trenton, N. J., is offering a new hydraulic control that governs disk adjustment for all models of Sutherland refiners.



*The Sutherland Refiner Corp.'s new hydraulic disk control, which is quickly and easily attached to existing refiners. All hydraulic lines feed in one side of the control panel, the two electrical lines in the other. Installation can be accomplished in 2 to 3 hr. by the mill's maintenance crew*

*Youtz-Slick Lift-Slab procedure of poured concrete building construction*

### Fischer & Porter

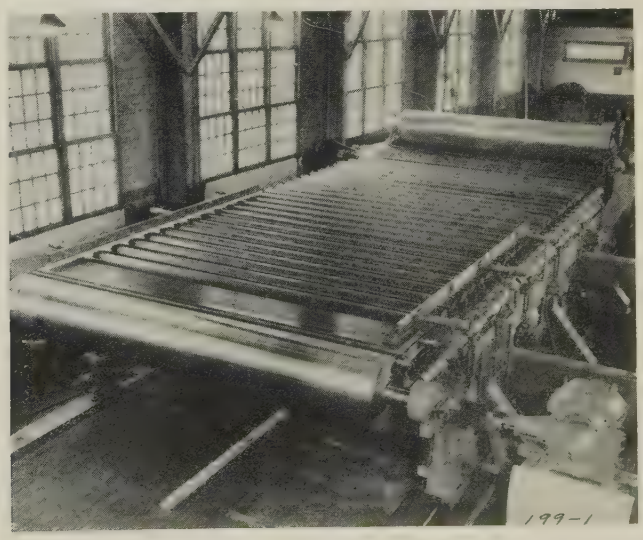
Fischer & Porter Co., Hatboro, Pa., has used a new method of poured concrete plant construction in the erection of its new fluid meter calibration laboratory. Known as the "Youtz-Slick Lift-Slab Procedure," it involves pouring the roof on the floor and then raising it to the desired height, thus eliminating 95% of the forms required for conventionally poured concrete buildings.

F. & P. has published a catalog (No. 2) describing process control instruments standardized and stocked for immediate shipment from Hatboro, Pa.

F. & P. has made the following appointments: Robert A. Stern, vice-president, Data Reduction & Automation Division; Louis H. Aricson, vice-president, International Division; Nathaniel Brewer, vice-president, Research; and Edward J. Querner, vice-president, Manufacturing.

### Downingtown

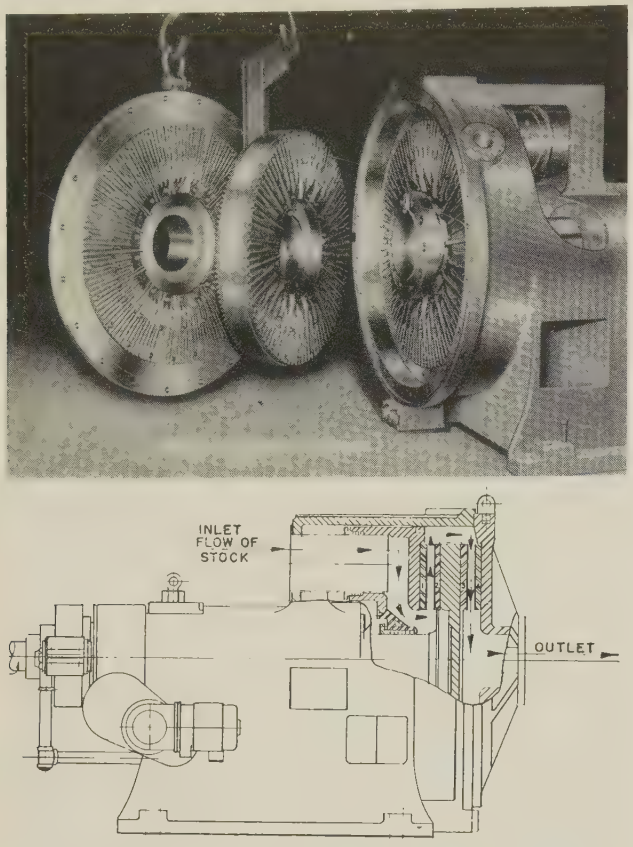
Andrew J. Kleiler, assistant chief engineer, and Clarence H. Butterfield, sales engineer, of Downingtown Manufacturing Co., Dowingtown, Pa., traveled to Finland recently to inspect a new Downingtown fourdriner in operation at Veisiluoto Oy. In Finland they were escorted by Tom Latimer, foreign representative for the United States Machinery Co., Downingtown's overseas' representative.



*New 192-in. Downingtown fourdrinier now in operation at Veisiluoto Oy, Finland. Above photo, taken in Downingtown shops before shipment, shows cantilevering arrangement used for easy wire changing. Stainless steel is used on all parts exposed to corrosive liquid*

JONES

E. D. Jones & Sons Co., Pittsfield, Mass., is offering a new, complete line of pressurized double disk refiners, designated the Jones Double D, in disk sizes of 26, 34, and 42 in. Power requirements will range from 200 hp. for the 26-in. unit to




*View and plan of the Jones Double D disk refiner.*

700 hp. for the 42-in. unit. Featuring a rugged straightforward mechanical adjustment and twin refining areas, the Double D provides great flexibility of operation and virtually no maintenance problems. Pressurized operation makes flow-through independent of disk design, so that flow-through, type of stock, consistency, and disk design may be varied independently without necessitating other compensating adjustments.

The Jones Co. will have its annual vacation shutdown the week of July 25.

RODNEY HUNT

Rodney Hunt Machine Co., Dept. 1R, Orange, Mass., has issued Industrial Roll Engineering Report No. 6, "Roll Surface Finishes" describing the selection of the right roll finish for various industrial uses.

INDUSTRIAL NUCLEONICS

Guardian Paper Co., Oakland, Cal., has installed an AccuRay basis weight gage, manufactured by Industrial Nucleonics Corp., Columbus, Ohio, to control the thickness of polyethylene.

W. E. Van Horne has been appointed assistant sales manager of Industrial Nucleonics.

GRACE

The Grace Chemical Co. has established its main office at its plant location in Memphis, Tenn. The Company's new address is P.O. Box 4906, North Station, Memphis 7, Tenn.

PENNSYLVANIA INDUSTRIAL CHEMICAL

William J. Roberts has been appointed director of research of Pennsylvania Industrial Chemical Corp., Clairton, N. J., succeeding A. L. Ward, who has retired. Nicholas C. Gangeni succeeds Mr. Roberts as assistant director of research.

SHEFFIELD

The Sheffield Corp., Dayton 1, Ohio, has issued two new data sheets on the Sheffield paper smoothness gage and the Sheffield porosimeter.

MONSANTO

Monsanto Chemical Co., Organic Chemicals Division, St. Louis, Mo., has published a technical bulletin (O-24) giving directions for six analytical methods for pentachlorophenol.

FREEPORT

Freeport Sulphur Co., 161 E. 42nd St., New York, N. Y., will install facilities to produce sulphur from a newly discovered salt dome deposit in the Louisiana tidelands, 60 miles southwest of New Orleans.

WALDRON

John Waldron Corp., P. O. Box 791, New Brunswick, N. J., has issued a bulletin (No. 52) describing the Waldron High-Speed Coupling.

MAGNUS

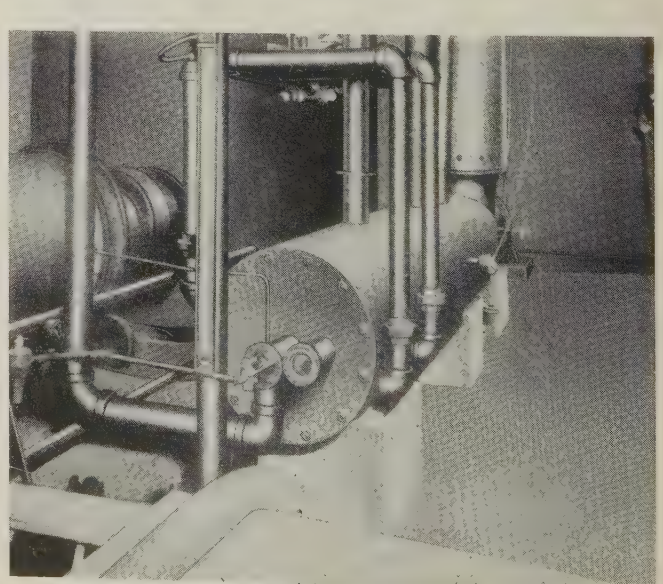
Acidex felt cleaner, made by Magnus Chemical Co., Garwood, N. J., has enabled a large midwestern mill producing high grade book paper to cut the time required for color changes from half a day to about $1^1/_2$ hr.

CHICAGO BRIDGE & IRON

Chicago Bridge & Iron Co., Chicago 4, Ill., has published a leaflet "Hortonclad" describing a composite metal having an integral and continuous bond produced by a new high-vacuum brazing process.

CHEMIPULP

Chemipulp Process Inc., Watertown, N. Y., is offering a radically new type compact sulphur burner, developed by Kimberly-Clark Corp., and marketed under the name Chemipulp-KC jet-type sulphur burner. A new burner is available in capacities of 1, $2^1/_2$, 5, 12, 15, and 25 tons per day.



*Chemipulp-KC jet-type sulphur burner*

Dow

Dow Chemical International Ltd. has opened a far eastern sales office in the Sanshin Building, Tokyo, Japan.

Snell

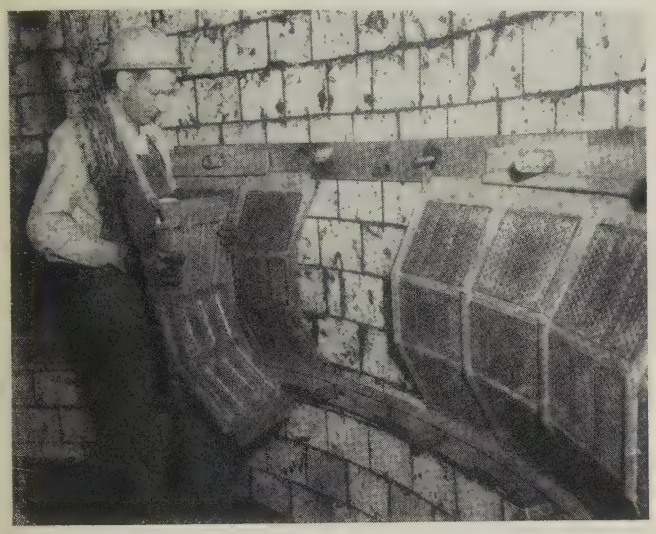
A two-year study recently completed by Foster D. Snell Inc., 29 W. 15th St., New York 11, N. Y., has proven that opaque waxed paper gives superior protection to vitamins in enriched bread, as compared with any clear transparent film.

Albany

The special motion picture, filmed at Albany Felt Co.'s main plant at Albany, N. Y., for the "Industry on Parade" television show, has been seen on 250 stations by an estimated 70 million viewers.

ESCO

Electric Steel Foundry Co., 2141 N. W. 25th Ave., Portland 10, Oreg., has developed an improved design of its stainless



*Installing Esco lap joint strainers*

steel Esco digester strainers, known as the Esco Lap Joint Strainer. One of the outstanding features of the new strainer is a great saving in installation time.

A-C

Allis-Chalmers Manufacturing Co., 828 S. 70th St., Milwaukee, Wis., has extended its WA Series impulse steam turbines to 16,500 kw.

William A. Yost, has been appointed vice-president of staff operations for A-C.

A-C has issued a bulletin (61B8222) describing the company's totally enclosed dry type transformers with NEMA Group 3 glass insulation for indoor or outdoor applications.

Graver

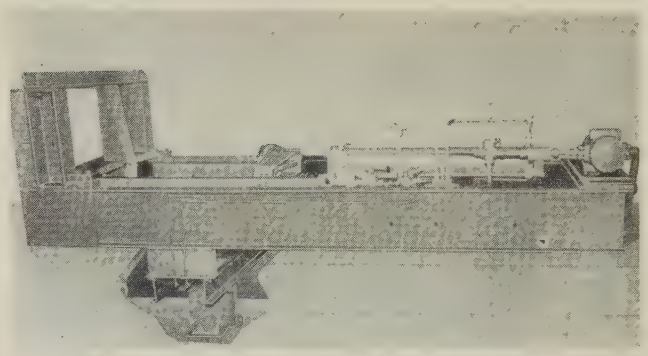
Graver Water Conditioning Co., 216 W. 14th St., New York, N. Y., is offering a new small size compact two-stage spray type deaerating heater designated the Graver SSC deaerating heater.

Graver has appointed the Atlas-Misrock Co., 110 N. 8th St., Richmond, Va., as sales representative.

J. O. Ross

S. W. Fletcher, president of the J. O. Ross Engineering Corp., New York, N. Y., has been elected a director of Columbian Carbon Co.

The Green Bay Paper & Pulp Co., Green Bay, Wis., is adding 18 new driers, equipped with a Ross Vapor Absorption System to its machine.



*Carthage hydraulic log splitter*

Elliott

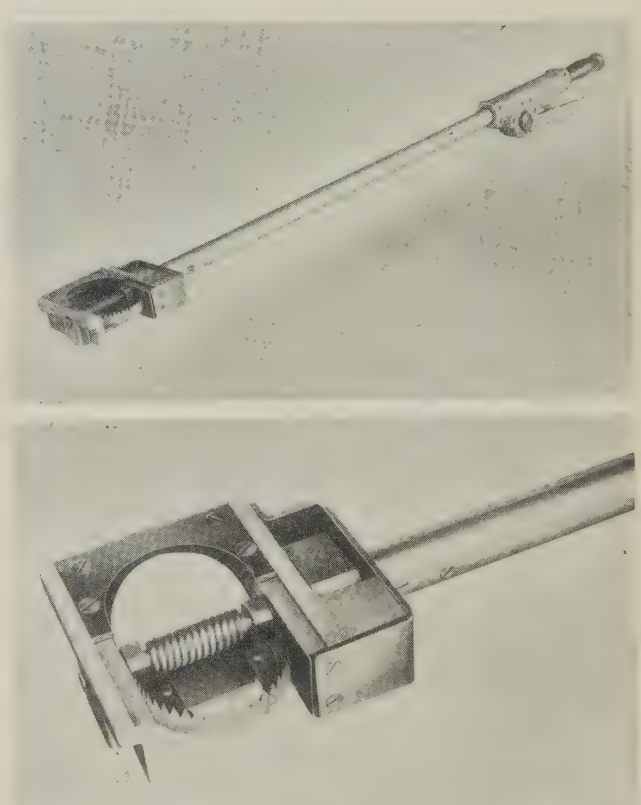
Elliott Co., Jeannette, Pa., has published a bulletin (PB4700-1) covering Elliott packaged adjustable speed drives.

Carthage

Carthage Machine Co., Carthage, N. Y., is offering a hydraulic log splitter which quarters logs in one stroke in a range of size to handle logs 24, 30, and 38 in. in diameter, and from 4 to $8^1/_2$ ft. in length.

Moore and White

The Moore and White Co., 330 E. Hunting Park Ave., Philadelphia 24, Pa., has introduced a new device known as the M & W-Cannan paper sampler, which snatches samples from webs moving at machine speed without danger of costly shutdowns caused by tears and pile-ups.



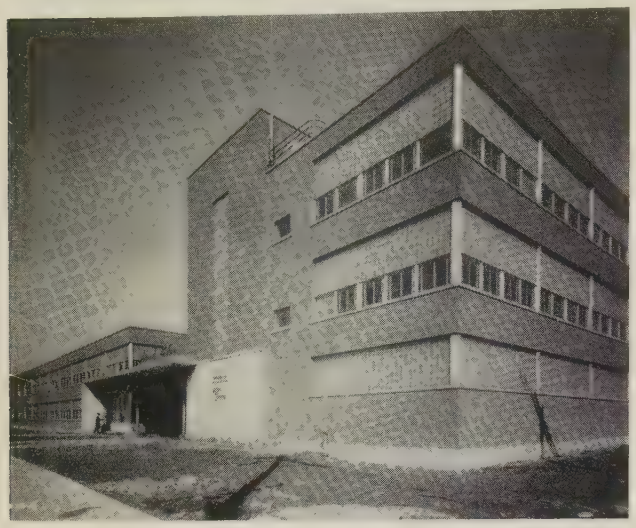
*The M & W-Cannan paper sampler, recently introduced by The Moore & White Co., is the first device ever developed which will snatch an accurate sample from any position on a moving web without tearing the web. The complete device is shown above and a closeup of the cutter head below*

RILEY

Riley Stoker Corp., Worcester, Mass., has published a bulletin describing Riley Refuse Fuel Burning Equipment.

NATIONAL ANILINE

National Aniline Division, Allied Chemical and Dye Corp.,



***Facade of new multimillion dollar Research-Engineering Center of National Aniline Div. of Allied Chemical & Dye Corp., located in Buffalo, N. Y. Center comprises two buildings, engineering building (left) and research building (right)***

has officially opened a new 63,000-sq.ft. Research and Engineering Center at its Buffalo, N. Y., plant.

ROOTS-CONNERSVILLE

Roots-Connersville Blower Division of Dresser Industries, Inc., Connersville, Ind., has established a Detroit sales office at 4917 Schaefer Rd., Dearborn 2, Mich., under the management of Daniel R. Fulton.

BECCO

Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y., has issued a bulletin (No. 65) describing peroxide bleach processes for Southern woods.

Becco has contributed 67 different publications to the industrial field on subjects ranging from surface treatment of metals to peroxide bleaching. Its most recent publication is a 175 page book on hydrogen peroxide.

OAKITE

Oakite Products, Inc., 19 Rector St., New York, N. Y., has established the Oakite Export Division to handle the distribution of Oakite cleaning and related materials and equipment in Latin America and overseas.

MILTON ROY

Milton Roy Co., 1300 E. Mermaid Lane, Philadelphia 18, Pa., has published a bulletin (No. 455) describing the use of controlled volume pumps in papermaking.

HARRIS-SEYBOLD

T. M. "Ted" Broadston has been appointed assistant sales manager for Harris-Seybold Co., Cleveland 5, Ohio.

GENERAL ANILINE

Philip M. Dinkins has been elected vice-president of operations of the Dye Stuff and Chemical Division of General Aniline & Film Corp., New York, N. Y.

SEMET-SOLVAY

The following new appointments have been made by Allied Chemical & Dye Corp.'s Semet-Solvay Petrochemical Division: F. M. Norton, vice-president, R. A. Lyon, production manager, W. J. Wixson, superintendent of the Tonawanda, N. Y., plant, and A. J. Koehne, assistant superintendent at Tonawanda.

ARIZONA CHEMICAL

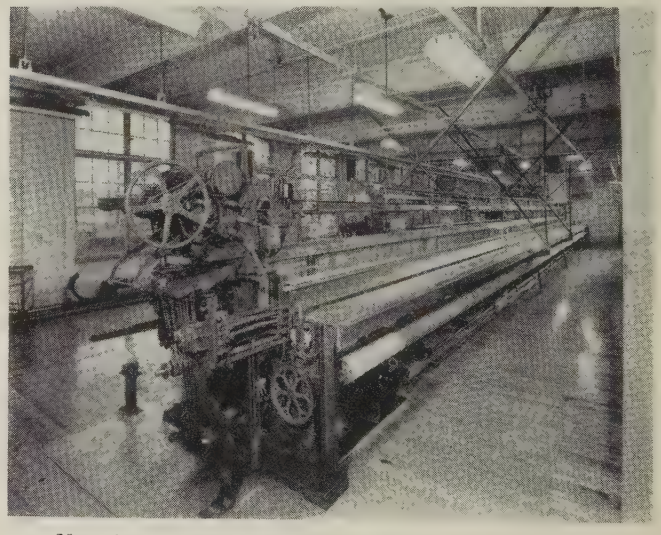
Arizona Chemical Co., Panama City, Fla., largest producer of tall oil products in the world, recently celebrated the 25th anniversary of its founding. The company was formed in 1930, and is jointly owned by American Cyanamid Co., and International Paper Co. Used in the paint, varnish, soap, detergent, linoleum, surface-coating and similar industries, tall oil is a mixture of fatty and rosin acids. It is derived from the spent black liquor residues when southern pine is made into kraft pulp.

BULKLEY, DUNTON

Bulkley, Dunton Processes, Inc., New York, N. Y., has appointed Backus & Spencer, Cleveland, Ohio, as representatives to handle the complete line of Bulkley, Dunton equipment.

HUYCK

F. C. Huyck & Sons, Rensselaer, N. Y., has installed a new



***New 680-in. loom installed at F. C. Huyck & Sons***

680-in. loom, the widest in the world for manufacturing paper machine felts.

DIAMOND ALKALI

Diamond Alkali Co., 300 Union Commerce Building, Cleveland, Ohio, has issued a wall chart giving 37 specific, successful suggestions for safely handling solid, liquid and flake caustic soda.

"The Story of the Chemicals You Live By" is the title of a new Diamond booklet which graphically depicts the company's family of chemical products.

Diamond has also issued a newly revised pocket manual reviewing its complete line of specialized sodium silicate chemicals.

EGAN

C. V. Blatter has joined the sales engineering staff, and A. G. Russell has been appointed sales engineer, for Frank W. Egan & Co.

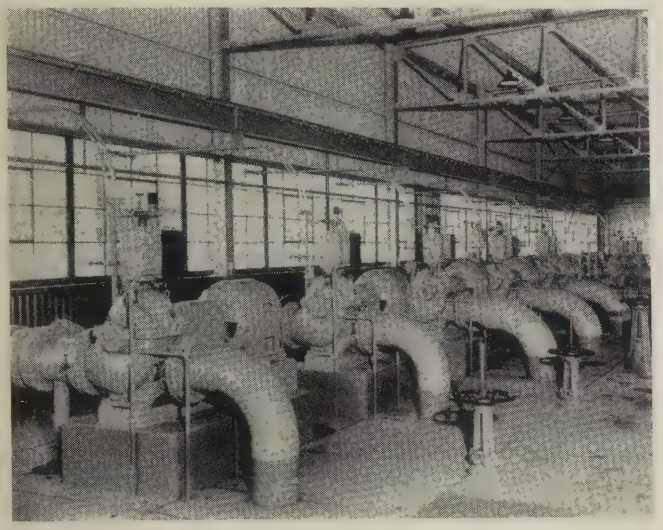
The Egan plant has recently been moved from Bound Brook, N. J., to Somerville, N. J.

### Rhodia

Rhodia Inc., New York, N. Y., has appointed the Naugatuck Chemical Division of Dominion Rubber Co., as representative in Canada, and Burhans-Sharpe Co., Seattle, Wash., as representative in the Pacific Northwest.

### De Laval

The De Laval Steam Turbine Co. has undertaken an extensive long range expansion program which will include the construction of a new building near Chicago and San Francisco, as well as in Trenton, N. J., and Houston, Tex



***Seventy three-million gallon per day double suction raw water pumps at the Fibreboard Products Co., East Antioch, Calif.***

The company, which is celebrating its 54th anniversary, was founded by Carl De Laval, whose experiments in the field of high speed, rotating machinery led to the development of the cream separator in 1877. The principles developed by Mr. De Laval found application in many fields. It was the need for a high-speed driver for the cream separator that lead him to the development of the impulse steam turbine, which included such outstanding elements as the expanding nozzle and the flexible shaft, thus making it possible to operate turbines in his day, at speeds that are not often surpassed even now.

### Foxboro

The Foxboro Co., Foxboro, Mass., has established 10 regional sales divisions under H. O. Ehrisman, a newly appointed general sales manager, and J. J. Burnett, field sales manager. The 10 regional sales offices and regional sales managers are: New England, H. H. Michelmore; New York, E. R. Huckman; Philadelphia, J. B. Deaderick; Pittsburgh, A. H. Shafer; Atlanta, E. W. Prendergast; Cleveland, H. L. Lee; Chicago, J. J. Connelly; Dallas, E. L. Stark; Houston, L. W. Parten; and San Francisco, R. E. Rogers.

### Bensing & Deeney

Bensing Bros. & Deeney, 3301 Hunting Park Ave., Philadelphia 29, Pa., has published a booklet on flexographic printing.

### Norbute

Norbute Corp., 383 Madison Ave., New York, N. Y., producer of uranium ore, has acquired Jackson & Church Co., process engineering equipment manufacturers of Saginaw, Mich., through an exchange of stock.

### Black-Clawson

Black-Clawson International, Ltd., is engaged in an extensive expansion program to enlarge its manufacturing capacity and facilities in the supply of complete paper and board machines. The program also includes increasing its capacity for supplying a complete line of stock preparation equipment and converting equipment.

### G.E.

The General Aniline & Film Corp. is using General Electric recording spectrophotometers to test dyestuff materials at its Rensselaer, N. Y., plant.

G.E. is offering a new Limitamp high-voltage meter control, saving more than 50% in floor space over previous models. A fact sheet on the new control is available from G.E. at Schenectady, N. Y.

### Combustion Engineering

The Dayton Power & Light Co., Dayton, Ohio, has contracted with Combustion Engineering, Inc., for a C-E Sulzer Monotube steam generator. This is the second C-E Sulzer unit to be ordered in this country, and it will be the first of the "once-through" type to operate at a steam pressure in the subcritical range, and will be larger than any such unit elsewhere.

### Scapa

Construction has started at Waycross, Ga., on the new drier felt plant of Scapa Dryers, Inc. Production is scheduled to begin late in 1955, and the manager of the new plant will

SCAPA DRYERS Inc. New WAYCROSS PLANT
"Partners in Enterprise"
SCAPA DRYERS LTD. LONDON ENG. - AYERS LTD. LACHUTE CANADA
Engineered and Constructed by
H.M. PAFFORD Jr. CONSTRUCTION CO.

***Ground breaking for new Scapa mill at Waycross, Ga. At left, Donald M. Brass, executive vice-president of Scapa Dryers, Inc.; with spade, Thomas Hindle, president of Scapa Dryers, Ltd.; at right, Edward H. Hall, president of Morey Paper Mill Supply Co.***

be Donald M. Brass, former manager of the Scapa London office. Morey Paper Mill Supply Co., Fitchburg, Mass., will be exclusive distributors for Scapa.

### National Lead

W. H. Woods has been appointed general sales manager of Titanium Pigment Corp., Division of National Lead Co., New York, N. Y. Earl W. Diener has been named assistant general sales manager of the corporation.

### Torrington

The Torrington Co., Torrington, Conn., has made the following personnel changes: M. E. Berglund, executive vice-president; L. W. Smith, vice-president of manufacturing; B. T. Virtue, vice-president of engineering; E. B. Thompson, vice-president of sales, W. R. Reid, Jr., assistant secretary and general sales manager; F. A. Pearce, vice-president of finance; W. Hudson, assistant treasurer; R. E. White, controller.

# Use of Microscopy in Pulp and Paper Mills—A Committee Survey

In order that it may be guided better in its work, the TAPPI Microscopy Committee sent out a questionnaire on the "Use of the Microscope in the Pulp and Paper Industry" to all members of the Association. A total of 599 replies were received from all parts of the world, principally the United States (452) and Canada (51). Many of the replies describing the use of microscopy came from companies related to but not actually in the pulp and paper industry. This brought out suggestions for the use of the microscope which are novel to pulp and paper technicians but may be of value as new approaches to old problems. On the other hand, the statistics must be considered in the light that microscopy is used to a far greater extent in these related industries than in the average pulp and paper mill. In addition, replies were received from many of the schools carrying on instruction in pulp and paper technology as well as research institutes specializing in this work. The conclusions reached were, therefore, not based on a strict quantitative analysis of the data collected but on the general pattern of the replies after due consideration of their source.

*Question* 1. How many microscopes do you have in your laboratory? Simple———, compound———, binocular———, electron———.

The replies showed: simple—176, compound—453, binocular—281, electron—7.

The most popular type of microscope is the compound binocular. Many mills checked both compound and binocular (unfortunately the question was ambiguous), which might mean that they had one microscope—a compound binocular microscope, or might mean that they had two microscopes—a compound monocular microscope and a compound binocular microscope. It is therefore difficult to say how many were monocular and how many binocular. Only seven replies indicated the presence of an electron microscope and, as might be expected, they were from the large allied chemical industries and not in a paper mill. Little significance could be deduced from the number of simple microscopes because many mills merely indicated that they had a number of magnifying glasses which are, in fact, simple microscopes. On the general pattern of replies, it is concluded that every mill has from one to three compound microscopes, depending on its size and that in most of the mills at least one of them is a binocular type.

*Question* 2. What accessories are available? Mechanical stage, polarizer, oil immersion lens, microtome, projector, camera, and others?

Replies: mechanical stage—444, polarizer—202, oil immersion lens—335, microtome—129, projector—201, camera—229.

This indicates that standard equipment for every pulp and paper mill should be a compound binocular microscope with attached mechanical stage. Many mills also have an oil immersion lens which is of value in solving slime problems. A large number of mills have cameras and projectors indicating wide interest in photomicrography as a useful technique. The use of the microtome in studying cross sectioning of paper is also popular. Among "others," the most common are phase contrast, micrometers (dish, stage, filar), and the dark field. Many of the "others" were listed by allied industries and might not have much significance to the average pulp and paper technician unless a description of how they are used were added. However, "others" listed several times are: stereoscopic microscope—8, vertical illuminator—8, hot stage—7, camera lucida—5, ultrapak—5, sodium vapor lamps—3, filters (Wratten, refractive index, fluorescent)—3, ultraviolet lamps—2, freezing attachment for microtomes—2. Several rather uncommon items such as microcine, microrefractometer, paraboloid condenser, polaroid camera were listed once.

*Question* 3. What use is made of the microscope?

The replies showed: fiber analysis—492, identification of dirt—438, filler analysis—241, examination of printing—234, examination of wires—223, examination of felt—182.

These replies indicate that every mill having a microscope uses it for fiber analysis and for dirt speck identification. Fifty per cent of the mills also use it for filler analysis and for the examination of wires, felts, and printing.

There were a great many "other" uses listed in about the following order of frequency: microbiology and slime problems; examination of coatings; examination of paper surfaces; beater control; particle size studies; study of cross sections of paper and board; identification of fiber species; paper and fiber measurements; study and identification of various beater additives; microchemistry; photomicrographs; corrosion studies; wax crystallography; degree of cooking; surface tension studies; examination of stones, cylinders, etc.; and several other highly special uses. These various uses of the microscope will be given further study by the committee.

*Question* 4. Do you employ a full time microscopist? If not, is someone assigned this work as a specific part of his job?

The answers indicate full time microscopists are not employed in paper mills but that several of the personnel are qualified to do microscopical work. This is performed whenever the need arises as part of their regular work. Many indicated that they do not have enough of these trained technicians and that only the chief chemist or head of the laboratory does the work. In these cases, there is indicated a need for such trained personnel. Among the allied industries, specially trained microscopists handle all the work.

*Question* 5. What could the Microscopy Committee do to make the microscope more valuable in your mill?

The following list was made up from the most frequent requests: (1) The need for a manual on the use and care of the microscope in the pulp and paper industry. Many asked for special instructions for untrained personnel. (2) A set of colored photomicrographs of stained fibers. (3) A source of reference fibers. (4) A source from which a set of permanently fixed stained fibers on slides may be obtained. (5) An up-to-date bibliography of latest developments and newest techniques. (6) Better stains, simpler and improved methods of preparing slides and identifying fibers. (7) Methods of identifying dirt specks with photomicrographs. (8) Methods of identifying fillers with photomicrographs.

These requests and the many others mentioned less frequently will be considered by the Microscopy Committee in a subsequent article. It may be well to point out, however, that one of the present projects of the committee is a microscope users monograph.

The Microscopy Committee acknowledges with special thanks the analysis of the questionnaires by one of its members, William Landes.

# LOCAL SECTION ACTIVITIES

***Reports of Meetings, Personnel, and Events***

## *Delaware Valley*

The March meeting of the Delaware Valley Section of TAPPI was held at the Engineers' Club on Spruce St. in Philadelphia, March 24, 1955. Approximately 100 persons were present to hear K. O. Elderkin, president of TAPPI and vice-president and general manager of Bowaters Southern Paper Corp., speak on "Paper Mill Management."

His remarks, which were repeated at the May meeting of the Southeastern Section of TAPPI, follow.

CARL F. ACKERMAN, *Secretary*

### Paper Mill Management—The Construction of the Bowaters Southern Mill

*K. O. Elderkin*

I HAVE been asked to speak on some phase of management. Since there are very few phases of management I know anything about, I will confine myself to telling you of some of the problems which faced management during the building and start up of the Bowater's newsprint and pulp mill at Calhoun, Tenn. It is one phase of management in which I have been deeply involved during the last 3 years.

Sales management and our financial people had a few problems to face and solve before operating management came into the picture.

This mill, with the woodlands to go with it, was estimated to cost 55 million dollars, so that it was deemed wise to have 60 million available so as to have a little margin for safety. Actually, the mill, when completed, and including timberlands, cost very nearly 60 million dollars. In order to be able to interest the banks and insurance companies who were eventually to loan us 45 million, it was necessary to convince these people that we could sell the output of the mill over a reasonable period.

Our American sales company—the Bowater Paper Co., Inc., of New York, has for many years been selling the output of Bowater's Newfoundland Company, largely in the south. Their customers and others in the southern states agreed to take the entire newsprint output from the proposed Tennessee mill for a period of 15 years if the mill was built.

As far as I know no privately financed company in our business has ever before been able to accomplish such a feat in sales management. In addition to this, the Bowater Paper Corp. of London signed a contract to take a minimum amount of 50,000 tons of unbleached or bleached pulp from the new mill for the same period at market price with a stipulated minimum price.

Because the mill would provide a stable source of pulp for Bowater's British mills, the British Treasury was persuaded to allow 15 million precious American dollars to provide the equity capital to finance the Tennessee mill. Persuading the British authorities to do this was quite a job in itself, and the result came as quite a surprise to people on both sides of the Atlantic.

In 1951 and 1952 when all this was going on, it was still impossible to undertake such a proposition as this without a Certificate of Necessity because building materials were still scarce and under government allocation. A description of the time, effort, and persuasion that went into the obtaining of this evidence of the U. S. Government's blessing on the project would fill a book and we haven't time to tell that story tonight. Suffice to say that such a certificate was granted on Feb. 19, 1952. This certificate allowed the write-off to depreciation of 45% of the cost of the mill in the first 5 years and was of tremendous help in arranging the financing which was finally completed in June 1952, with agreement by several insurance companies to buy $37\frac{1}{2}$ million of our bonds, and the promise by several banks to loan us up to $7\frac{1}{2}$ million on our notes. With our own 15 million dollars we were now ready to build and ground was broken in June 1952.

For several years before this a team of Bowater engineers and mill management people had been searching the North American continent for a suitable spot on which to erect a newsprint and pulp mill. This group flew thousands of miles viewing timberlands from the air and traveling from place to place examining possible mill sites. They covered eastern and western Canada, the western United States and the entire south. By the end of 1951 the search had boiled down to a point where the Bowater people were arguing among themselves as to which of two locations would serve their purposes better.

They finally settled on a spot on the north bank of the Hiwassee River where it runs between the two small towns of Charleston and Calhoun, Tenn. The mill site is 40 miles northwest of Chattanooga on the west side of U. S. Highway 11, which is the main road between Montreal and New Orleans. The site contained 1800 acres and sloped gradually up from the river to low hills about 100 ft. above the river.

It was a lovely spot when I first saw it in the lush green of April 1952, a few days after I came to Bowater's to take on the job of supervising the building and operating the enterprise. A fine herd of cattle was grazing on the peaceful slope, the Smoky Mountains rose blue in the east, and the Hiwassee River flowed serenely through the landscape. I determined

*H. C. Brill, E. I. du Pont de Nemours & Co. Inc.; K. O. Elderkin, Bowaters Southern Paper Corp.; and E. C. Padavic, Container Corp. of America*

K. O. ELDERKIN, Vice-President and General Manager, Bowaters Southern Paper Corp., Calhoun, Tenn.

then and there that when our mill was completed it should disfigure the landscape as little as possible. The architect employed to see that this was done has done an outstanding job. I have yet to hear anyone say that we have created an unsightly blot on the landscape.

You may ask "What were the particular features which determined the selection of this mill site?" I can enumerate them as follows:

A site where grading to a flat building surface would be relatively cheap and where good foundations could be had. This site is on a limestone base, overlaid with about 30 to 35 ft. of red sandy clay.

A supply of fresh water of suitable analysis was available by pumping it out of the Hiwassee River.

Rail transportation was provided by a main line of the Southern Railway, which ran within 20 yd. of the site. U. S. Highway 11, and several other adjacent highways, offered road transportation, while the Hiwassee River with its 9-ft. dredged channel to the Tennessee 18 miles downstream, gave us a water connection to the great inland waterways of the Nation.

The site was located near the center of gravity of our customers.

The Tennessee Valley Authority offered cheap, abundant, and dependable electric power, and the wood from its many fine plantations.

The area offered abundant supplies of short leaf, loblolly, and Virginia pine, which could be brought to the site by water, rail, or road.

The main natural gas line between Chattanooga and Knoxville runs through the site and provides fuel for boilers and lime burning.

The Hiwassee, where the flow is regulated by five power plants and five reservoirs upstream on its two branches, provides means for the necessary dilution of mill wastes before they are delivered to the Tennessee River.

Limestone and chemicals were available at reasonable distances from the mill.

The best feature of the site which was perhaps not given its full weight at first was that it was located in a part of the country where people like to live. The TVA lakes offer unsurpassed opportunities for recreation. The climate is good. The woods and mountains offer wonderful scenery and opportunities for hunting, hiking, and auto trips. Two cities of medium size, Chattanooga and Knoxville, are within easy reach, and two smaller towns, about 13 miles on either side of the mill, Athens and Cleveland, offered pleasant places for the people to live. Right at the mill two villages were ready for development for those who liked to be near their work.

These opportunities for good living, as it turned out, combined with the attraction of a new and modern plant, allowed us to attract to the Calhoun mill the best staff, operators, and workmen in the industry. Over 35,000 applied for work, from which 750 were selected.

During 1951 the J. E. Sirrine Co. of Greenville, S. C., had been making preliminary plans and estimates on which to base the company's financing. The granting of the Certificate of Necessity was the signal for the engineering to proceed at full speed, aimed at a definite project at a definite location. Early in March I met in Greenville with Sirrine's people and with Bowater men from England and Canada, as well as the United States, and through night and day sessions lasting a week, we hammered out the basic plans for the project, and Sirrines got down to design work in earnest.

You may be interested in some of the decisions which had to be made by management and engineering at that time.

First, we had to determine the best probable width of the two newsprint machines to be installed. On an analysis of the requirements as to newspaper press widths and roll sizes in the southern states, it was determined by our sales company that the maximum trimmed width of the sheet should be 228 in. In order to give better edges and better wet end running conditions we gave ourselves 6 in. more wire width than usual so that the machines have 254-in. wires. The length of the wire was determined, based on experience with many other news machines, and modified by the fact that we hoped to run at higher speeds.

It was early determined, based on my experience with the first suction transfer at Crossett, that these machines should be carefully designed to incorporate this feature. These were the first news machines which had suction transfers built into their original design.

Having settled the general specifications of the machines we then had to decide how fast we could be certain of running these machines, and on how fast we *might* be able to run them sometime in the future. We could not reasonably provide more pulp capacity than enough to take care of the former, but we must provide for being able to extend or speed up our facilities to take care of the latter—if higher speeds became possible.

No machine in the south, of the four in operation at that time, had ever run over 1500 ft. for any extended period, so we adopted that figure as a guide to the maximum amount of pulp capacity which should be provided. No news machine in the world at that time had ever exceeded about 1850 f.p.m., so we decided to plan our paper machines for a maximum speed of 2000 ft., and to make plans for extension of the other facilities for future expansion up to this speed. Planning for the future is one of management's most important functions, and it is in this area that most mistakes are made.

Usually the only tools in management's hands are statistics, which, while an excellent record of the past, are usually a poor guide to the future, unless mixed with good judgment, a lively imagination, and some reliance on a good crystal ball.

We know now that we made a serious error in judgment in gaging the effectiveness of the new engineering developments in our paper machines, particularly the suction transfer. We think now that our machines should have been designed for even higher speeds and that we will be running at maximum designed speeds long before we had expected. We have already been running for an extended period at speeds in excess of 1800 ft.

Another error was in underestimating the capacity of our grinders. These grinders are the largest which have been built. They are Waterous Great Northern grinders, built for 5 ft. 3 in. wood, which is the usual length of pulpwood sticks being cut in our area. Based on past experience, we expected these machines to produce a maximum of 43 tons of good groundwood per stone. We expected these stones to absorb at this production not more than 3750 hp. Thinking that for once we would provide a grinder with enough power, we put 4500-hp. motors on each grinder. Experience has shown that we can produce over 50 tons per stone, and that our motors are too small. We have ordered an additional grinder, and this one is to have a 6000-hp. motor.

Management's mistake here was that again we did not have the imagination to realize the over-all cumulative effect of modern engineering developments through the whole system.

In the past, in making newsprint at very high speeds, the quality of groundwood has had to be very carefully controlled with just one function in mind. It had to have just those qualities which would make a sheet that could be pulled off the wire at high speeds onto the first press felt without too many breaks. The suction transfer has eliminated the need for those particular qualities (whatever they might have been) and now allows us to produce a quality of groundwood which is solely determined by the requirements for printing on a printing press. It so happens that the elimination of the old very exact requirements allows us to make more pulp better suited to its ultimate use.

For years southern mills have sought ways and means for

preventing deterioration of their wood in storage during the long, hot, humid Summers. In the past, wood inventories had to be kept at a minimum during the Summer—then each Fall there was a wild rush to build up stocks in preparation for wet weather or cold spells in winter, which make wood scarce.

We have known for some time that wood immersed in water will not deteriorate. At Bowater's, management decided to do something about it, and the underwater wood storage which can hold 38,000 cords of wood was built. It has been fully described in the trade papers, so that I do not have to give you the details here.

It accomplishes three things: (1) It allows the wood procurement department to take wood when it is available. It allows wood contractors to deliver wood at a steady rate, without having to cut back their quotas at times when they can produce most economically, and having to press for more wood when its procurement is most difficult. (2) It prevents deterioration of the wood. (3) It delivers wood to the mill at practically constant moisture.

So much for the original planning and some of the engineering features of the mill.

After Sirrines began engineering in the Spring of 1952, their work progressed under full steam until the mill was practically completed.

One of the problems of management was to keep an eye on engineering to see that it was coordinated at all times with the work of the building contractors, machinery erectors, etc.

The development of the personnel of such a project as this should be of interest. When I came into the picture, Bowater's provided four men. One was the man who was to be mill manager and my principal assistant. The secretary of the new company was provided by our Newfoundland company, while the controller and treasurer came from our New York company. From the Bowater organization all over the world we were able to draw on the help of experts in many lines on a consulting basis. The forestry consultant who had been working on the project for several years continued in that capacity, and immediately began to lay plans for buying the large areas of timberlands which such a mill needs on which to raise its pulpwood, and provide reserves.

I brought an electrical engineer with me from Crossett. Until we located a suitable chief engineer, I served in that capacity as well as in that of general manager.

One of the first men hired was the best industrial relations man I knew as he was to bear the responsibility of providing the man power for this project. With his guidance, and always with the approval of the new employee's supervisor, we began to accumulate our work force. First on the list were woods manager and assistant, purchasing agent, chief engineer, traffic manager, and assistant industrial relations manager. Then each staff head began to select his superintendents with the aid of the industrial relations people, and finally the superintendents selected their own workmen, always guided by the people in the industrial relations department.

The woods manager, with help from industrial relations, organized and staffed his central office and five district offices, each with a district superintendent, assistant, and staff. This process was not completed until about 3 weeks before the department being manned was ready to go into operation.

In staffing the mill we had to hire about 200 people from within the industry—the rest were selected from other walks of life, and were trained on the job to do the particular operation for which they were hired. The organization of these training programs was quite a job in itself.

That we picked our men well and trained them effectively is, I think, proved by the fact that few mills have had as successful a start as we have had, and have attained such high standards of quality and production at such an early date.

The mill was designed for 125,000 tons of paper and 50,000 tons of pulp per year. We are currently producing at an annual rate of over 160,000 tons of paper and over 60,000 tons of pulp for export.

*R. G. Macdonald, TAPPI; K. O. Elderkin; R. I. Thieme, Scott Paper Co.; and J. D. Lyall, Armstrong Cork Co.*

Our paper has been enthusiastically received in the pressrooms right from the beginning. Those results can only be accomplished by good men, properly trained.

I am particularly proud of my organization so if I brag about them a little, please forgive me.

One of the problems which management had to face, and which was solved by the industrial relations department, was how to house 750 prospective employees. This was done through a program of education, combined with cooperation with various local organizations.

First we let it be known that Bowater was not going into the real estate business—that was going to be left to the real estate people.

Early in the program a representative group of citizens were brought together and told of our plans and the effect they would have on the surrounding community. They were taken to visit an operating paper mill community so they could see at first hand what happens to an area when such an industry as ours moves in. They were encouraged to form the necessary groups to make orderly plans for the changes to come. We have had the most complete cooperation from these groups that we could possibly expect. The existing towns of Athens, Cleveland, Charleston, and Calhoun somehow managed to accommodate the construction force, which at one time reached 2300 men.

The towns of Charleston and Calhoun provided for zoning and organized a utilities commission, which financed and built a complete water supply system for the two towns.

The FHA was brought into the picture and housing contractors built homes for the new employees in Charleston and Calhoun. Many employees built their own homes in the area or purchased them Some rented, some found boarding places as temporary accommodation until they could build for themselves.

The $3,500,000 payroll at the mill and the wood buying in the area is having its effect so that the secondary wave of immigration, which comprises the butchers, the bakers, and the candlestick makers, to supply the needs of our employees, is already beginning, and Charleston and Calhoun are beginning to how symptoms of becoming boom towns.

While we are talking about people, I want to point out to you a change which is occurring in our industry, and in fact in all industry. Years ago in any paper mill the operating workmen were the largest group at the mill at any time. With continuing approach to what is now called "automation," the operating group is shrinking in proportion, while other groups are increasing.

In our mill during the day shift, there are more maintenance and repair men than there are operators. There are also

more office people, including daytime supervision and head office staff, than there are operators.

During the night shifts, there is only one man in the mill for every $400,000 of plant.

These changes are making new problems for management. The average wage per employee is coming up and raising the average standard of living because of the larger proportion of skilled men. The selection, training, supervision, and care of our work force is becoming increasingly important, and must have more attention from management. The increasing complexity of the machinery and controls, and the higher skills and scientific learning required, open new fields for technical men of all kinds. Management must do a much better job in public relations and in making known to our young people the wonderful opportunities for a career in papermaking if we are going to have available to us in the future the kind of men we are going to need to run the mills of the future.

Now, before I close this rambling report, I want you to take a look at what management has facing it in the future. Several groups have, within the last year or two, made rather detailed studies and researches to try to determine the future of our industry. One of these studies, carried out at Stanford University by the Weyerhaeuser Timber Co., is perhaps outstanding, and if you haven't read it, I strongly recommend that you do. It is called "America's Demand for Wood 1929–1975."

All authorities agree that the demand for paper in this country is going to double in the next 20 years or so. America's use of paper has doubled every 12 to 15 years for the last century, so the possibility of it doing so again in 20 years does not seem at all impossible to me.

This means that management must find the means to provide new capacity each year to produce $1\frac{1}{4}$ million tons of new paper and at the same time replace its worn out plant. One to one and a half million tons per year of new plant seems a reasonable expectation. Since plants take at least 2 years to build, this means 3 million tons of plant in construction at all times during the next quarter century. We must produce the trees—we must find the money—and we must find and train the men.

It looks from here as though management has quite a job ahead of it, and it looks as though TAPPI—which means you—will have to provide a lot of that management.

## *Ohio*

The Ohio Section of TAPPI held its annual Ladies Night on May 12, 1955 at the Hartwell Country Club in Cincinnati, Ohio.

A group of 288, including members and their wives, attended this gala evening. A cocktail hour, steak dinner, election of officers for the 1955–56 season were followed by dancing and entertainment. The ladies present were the guests of the Ohio Section.

***Newly elected Chairman William Aiken receives gavel and congratulations from outgoing chairman, Harold Joiner***

***W. M. Aiken, Gardner Board & Carton Co. and H. R. Joiner, Champion Paper & Fiber Co.***

Chairman Harold Joiner, Champion Paper & Fibre Co., opened the meeting and welcomed everyone present. He then held the election of new officers, and the following slate was elected for the 1955–56 season:

*Chairman*—William H. Aiken, Gardner Board & Carton Co., Middletown, Ohio
*Vice-Chariman*—Ellsworth Shriver, Mead Corp., Chillicothe, Ohio
*Recording Secretary*—Virgil Perry, Harding Jones Co., Middle town, Ohio
*Corresponding Secretaoy*—Frank C. Duvall, Black Clawson Co., Middletown, Ohio

Malcolm G. Lyon, Champion Paper & Fibre Co., was appointed program chairman for the next year.

This was the last meeting of the Ohio Section for the 1954–55 season, and concluded a very successful year. The Ohio Section is looking forward to another big year starting next September.

E. W. Petrich
*Recording Secretary*

## *New England*

On June 3 and 4, 1955, approximately 120 members and guests convened at the Oceanside Hotel in Magnolia, Mass., for the annual meeting of the New England Section.

The technical portion of the meeting consisted of mill visits to the Robert Gair Co., Inc., Haverhill, Mass., and to the Paper Engineering Dept. of Lowell Technological Institute in Lowell, Mass.

Two technical papers were presented at the Oceanside Hotel; the first on June 3, which was entitled "The Development of a Quality Control Program for a Paper Mill" by C. M. (Cap) Howell, professor of paper technology, Chemical Engineering Dept., University of Maine, Orono, Me.

On June 4, Horace N. Lee of the Paper Engineering Dept., Lowell Technological Institute, Lowell, Mass., presented a paper entitled "Microscopy—Stop, Listen, and Then Look." Mr. Lee's paper was very appropriately supplemented with actual demonstrations on procedures and results using the microscope.

The annual business meeting was held on June 4, with the following business being transacted:

The acceptance of the slate of officers presented by the

***John Lewis, Lowell Technological Institute; C. M. Howell, University of Maine; H. N. Lee, Lowell Technological Institute; and F. S. Klein, Byron Weston Co.***

Nominating Committee for the year 1955–56. The proposed and accepted slate is as follows:

*Chairman*—G. L. Benson, St. Regis Paper Co., East Pepperell, Mass.
*Vice-Chairman*—C. L. Reece, Westfield River Paper Co., Russell, Mass.
*Secretary-Treasurer*—R. W. Ramsdell, Hercules Powder Co., Holyoke, Mass.

The following members were re-elected to serve as members of the Executive Committee:

Miss Helen U. Kiely, American Writing Paper Corp., Holyoke, Mass.
Joseph T. Loomer, Robert Gair Co., Inc., Uncasville, Conn.
Ronald Malloch, American Writing Paper Corp., Holyoke, Mass.
John Lewis, Lowell Technological Inst., Lowell, Mass.
F. L. Simons, Crane & Co., Inc., Dalton, Mass.
William Stillman, Bird & Son, Inc., E. Walpole, Mass.
C. I. Horton, Philadelphia Felt Co., Norwalk, Conn.

The following members were elected to serve as members of the Executive Committee for the first time:

E. W. Strecker, Esleeck Mfg. Co., Turners Falls, Mass.
P. J. Fitzpatrick, American Cyanamid Co., Boston, Mass.
Richard Dempsey, A. E. Staley Mfg. Co., South Hadley Falls, Mass.

In addition, the outgoing chairman, F. S. Klein, Byron Weston Co., Dalton, Mass., was elected to serve in an *ex-officio* capacity for the term of 1 year.

The Nominating Committee consisted of: P. P. Gooding, Strathmore Paper Co., W. Springfield, Mass., as chairman; Charles Lewis, Peter Cooper Corp., Boston, Mass., and Walter Wentworth, Clinton Sales Co., Boston, Mass.

The membership present unanimously accepted the change in the New England Section by-laws and also the addition of an amendment to the by-laws.

The change in the present by-laws consists of increasing the number of members of the Executive Committee from 12 to 13. The amendment to this article consists of the outgoing chairman of the Section to act as an *ex-officio* member of the Executive Committee for 1 year.

R. W. Ramsdell
*Secretary-Treasurer*

## *Empire State (Western District)*

Conducted tours of two plants of the J. W. Clement Co., Buffalo printers, preceded the February meeting of the Western District of the Empire State Section of TAPPI, held at the Park Lane in Buffalo, N. Y., on Feb. 2, 1955.

About 35 members and guests were present at this meeting, at which Calvin Seaquist, head of the J. W. Clement's Production Research Department, presented a very interesting talk on printing.

### *April Meeting*

The Western District's April meeting was held at the Prospect House, Niagara Falls, N. Y., on April 6, 1955, with 43 members and guests in attendance. A panel of four representatives of paper mill suppliers discussed "New Materials for the Paper Industry", the topic of the evening for the Western District's Annual Suppliers' Night.

F. A. Strovink, eastern regional manager, Paper Chemicals Dept., American Cyanamid Co., discussed various new products which American Cyanamid now has available, as well as older products which have been improved. Among the products Mr. Strovink discussed were wax emulsions; azite fluidifier for coatings; Cyron size; an acrylic base emulsion for greaseproofing; a dry strength resin which produces a 600 to 1000% increase in fold and a 40% increase in bursting strength and tensile; and a cationic anti-static agent also used as a rewetter or disperser.

Talks presented by the other three speakers, M. L. Cushing, chief paper chemist, Stein Hall & Co.; S. F. M. Maclaren, divisional sales manager, Penick and Ford, Ltd., Inc.; and F. H. Denham, technical director, Paper Mill Dept., R. T. Vanderbilt Co., Inc., follow.

### Guar Gum as a Dry Beater Additive

*M. L. Cushing*

During the last decade the paper industry has made increasing use of additives composed of or derived from natural gums. A series of these hydrophilic galacto-mannan polymers, blended or treated with certain chemicals to aid in the dispersion and flow distribution to various stages of the papermaking process is commercially available under the generic trade name of "Lycoid."

The particular type of product under consideration for this session is composed of the galacto-mannan gum guar, the cold-water soluble reserve carbohydrate of the guar legume seed.

The use of guar gum as a wet-end additive is no longer new or novel, having been well documented by the work of The Institute of Paper Chemistry, our own publications, and by commercial exploitation in many phases of papermaking.

What we believe to be novel and worthy of special attention is the development of a product which can be used as a dry additive in the beater or early stages of stock preparation which is free from the usual difficulties of dispersion. The rapid wetting and swelling of other guar products leads to gumminess, lumps, and trouble with shiners, fish-eyes, picking on felts, etc. Our processing results in a product which wets out completely before swelling takes place. The time of inhibition can be varied so that products can be formulated to disperse in waters of different temperature ranges. Thus, there is offered one product for water temperatures up to 100°F., a second for temperatures from 100 to 125°F., and a third product from 125 to 165°F.

While designed to be added dry in the very early stages, usually before beating or refining, these products can be slurried or cooked and added at later stages such as headbox or fan pump.

When present in the stock preparation waters before beating or refining the result of the normal beating schedule is a freer, faster draining stock having higher strength values (burst, fold, tensile, tear) than normal for a given mechanical working. As a further result there is an improvement in for-

M. L. Cushing, Chief Paper Chemist; Stein, Hall & Co. Inc.; New York, N. Y.

mation, opacity, brightness, pick test, surface uniformity, ink receptivity, etc.

Concurrently with the improvement in test values of the finished sheet there appears to be an increase in wet web strength. That is when the gum-treated furnish is fed to a machine where frequent couch gap breaks are occurring these breaks immediately cease and the sheet runs free of wet-end breaks. It is possible that this may be due to formation improvement alone and not to an actual wet web strength gain.

There usually results a denser, less porous sheet. Naturally, there can be advantages or disadvantqges for this occurrence, advantages where one wants to eliminate pin holes, for instance, and disadvantages where an open, bulky, absorbent sheet is desired.

When used in a mineral filled sheet the percentage of filler rises (the composition of the furnish being held constant) with little or no drop in strength tests. Accompanying this is a marked decrease in two-sidedness.

Suitable technical and high-grade modifications of the product are available for various grades of paper. Newer modifications are available to increase the retention of titanium pigments from coated or tub sized broke: Modifications compatible with paper dyes are available where required.

The usual levels of addition range from 3 to 20 lb. per ton, with the bulk of the use being at the 5 to 10-lb. per ton level.

Prices of these products are in the $0.25 to $0.30 per lb. range. One pound of guar gum product normally does the job of 5 to 10 lb. of starch, thus making the cost per ton of finished paper well within reason.

## Penford Gums

*S. F. M. Maclaren*

Most of you are already familiar with "Penford Gums" and know that they are essentially hydroxy ethyl ether derivatives of cornstarch, the hydroxy ethyl ether groups being attached directly to the starch molecule by strong ether linkages.

Further information pertaining to the manufacture of these products will be found in U.S. pat. 2,516,632–3–4 and, in the United States, they are manufactured solely by Penick & Ford Ltd., Inc. Although Penford Gums have the physical form and appearance of the original cornstarch, the addition of the hydroxy ethyl ether groups has created a new series of chemical compounds with noticeably different and improved characteristics which make them highly adaptable to many processes in the industry.

The starch molecule, which may be considered to be essentially a polysaccharide or polyalcohol, contains many hydroxyl groups and these are responsible for many of its properties.

One of the prominent characteristics of these hydroxyl groups is the attractive force they have for each other or for water or other hydrophilic materials.

The attraction these hydroxyl groups have for water increases when a slurry of raw starch in water is heated so that at the gelatinization temperature it becomes greater than the attraction the molecules have for each other and the starch is said to paste, hydrate, or disperse. However, even in the cooked or dispersed state the associative tendency of the starch molecules for each other is apparent and is believed to be responsible for some of the undesirable changes evident when a cooked starch paste or sol is cooled, aged, or dried.

The tendency of a cooked cornstarch paste to thicken or gel on cooling or aging is due to the tendency of the dispersed or hydrated molecules to associate with each other with the resulting loosely cross-linked molecular network of still hydrated starch having an increased viscosity or even setting up to a stiff gel. In some instances this association between starch molecules progresses to the point where it becomes irreversible under normal conditions and some of the starch may actually precipitate from solution. Frequently, as when a starch paste or film is dried, this irreversible association between molecules takes place and a horny insoluble mass is formed which does not readily rewet or redisperse back to the previous hydrated sol form. The term retrogradation is usually applied to this irreversible molecular association.

It may be deduced, therefore, that the substitution in the starch molecule of any chemical groups which will modify or overcome some of the properties of the hydroxyl groups may greatly change the properties possessed by the starch itself. This has, indeed, been demonstrated in the case of the Penford Gums. The replacement of a relatively small proportion of the hydroxyl groups in the starch molecules by hydroxy ethyl ether groups gives a product still in the granule form which has markedly different and, for many uses, vastly improved properties.

Among these improved properties possessed by the Penford Gums are the following: reduced gelling tendency; improved viscosity stability on cooling or aging; decreased retrogradation tendency; increased film solubility; lowered gelatinization temperature; improved viscosity stability on heating; improved water-holding ability; more cohesive or "glutinous" paste character; improved film forming characteristics; clearer, more flexible films; increased reactivity to borax and resins; more resistant to biological spoilage; good compatibility; water hardness and pH not critical; good color stability; depolymerization by enzymes. The Penford Gums are produced with several levels of ether group substitution and a wide range of modifications or fluidities. For convenience they have been arranged in three separate groups, the members of which have been designated the 200, 300, and 3000 series, respectively.

The various products in the 200 and 300 series have been converted so that their paste viscosities cover the range of the usual unmodified and thin-boiling cornstarches. The members of the 3000 series have been still further modified so that their paste viscosities correspond with those of the familiar cornstarch dextrines. For example, the three available products in the 3000 series, namely, 3040, 3070, and 3090 may be conveniently prepared in concentrations as high as 35, 45 and 65%, respectively.

The Penford Gum 200 series has a lower degree of hydroxyethyl substitution with a resulting gelatinization range of about 10°F, lower than that of ordinary cornstarch.

The Penford Gum 300 series has a higher degree of substitution so that its gelatinization range is lowered to about 30°F. below that of native cornstarch. In addition, the members of this series possess those improved properties typical of the Penford Gums (hydration, cohesiveness, paste and film clarity, resistance to gelling, etc.) to a greater degree than the 200 series members.

Because of the decreased "set-back" (viscosity increase) on cooling or aging pastes of all three series of Penford Gums can frequently be prepared in concentrations somewhat higher than can conventional starch products having comparable hot-paste viscosities. In the relatively short time they have been available, the Penford Gums have been widely adopted by the paper manufacturers and converters. Their use is frequently advantageous in beater or furnish sizing, tub, size press and calender sizing, various coating applications both at the size press and on the conventional on and off-machine coaters, corrugating, solid-fiber laminating, miscellaneous lining, laminating and winding operations, and as paper bag adhesives.

For beater or furnish addition Penford Gums 200 or 300 are generally employed. As the gelatinization temperature of these Penford Gums is materially lower than that of ordinary cornstarch, the inclusion of up to 5% on the fiber basis materially increases the internal fiber bonding in the dried sheet

S. F. M. Maclaren, Divisional Sales Manager, Penick & Ford, Ltd., Inc., New York, N. Y.

with consequent improvement of the bursting strength and other sheet properties. Surprisingly beneficial effects on sheet finish and grease resistance are often observed. Sheets are currently being made with Penford Gum 300 in the furnish range from lightweight waxing stock to high caliper board.

As far as surface sizing is concerned Penford Gums are widely used at the tub, size-press, and calenders for their effect on the sheet strength and stiffness as well as on its surface characteristics. Where surface effects are desired primarily, the viscosity of the sizing solution used should, in general, approach the maximum viscosity practicable for the operation in question. This tends to minimize size penetration and results in relatively more starch remaining as a surface layer where it is more effective in improving surface characteristics. Such a thin surface layer is also surprisingly effective in increasing the strength characteristics as wax-pick test, burst, and tensile. However, where these latter tests need to be still further improved, a more penetrating size may be preferable. Thus, the use of a higher concentration of a thinner Penford Gum will usually contribute to a greater added weight, improved internal bonding, and greater sheet strength.

Where bursting strength or tensile increase is desired the Penford Gums are commonly applied at both the size press (or tub) and/or the calender stacks. In this case an appreciable added weight is desired so the thinner products (280 and 380) are usually suggested at concentrations of from 6 to 12% with the lower concentrations being more common on paper and the higher solids levels being used primarily for the heavier papers and boards. The sizes are applied at 130 to 170°F. at the size press and usually 170 to 190°F. on the calenders, depending on the conditions of operation.

As mentioned above the Penford Gums are superior to ordinary starches in their water-holding and film-forming characteristics. Their films are consequently more continuous in nature and this continuity makes such a film a superior barrier to hydrophobic materials such as grease, wax, varnish, lacquer, etc., and materially lessens the rate of penetration of hydrophilic substances as animal glue, starch adhesives, coatings, etc. The results frequently approach those obtained with many of the more expensive synthetic and natural gum film formers and usually are obtained at a considerably lower cost.

Large quantities of the Penford Gums are currently being used for controlling the wax penetration on bleached kraft milk bottle stock, minimizing lacquer and varnish absorption in label stock, reducing the penetration of animal glue in gummed tape, and for improving the results obtained when board or paper is subsequently printed with high-gloss inks.

The high reactivity of the Penford Gums enables them to be advantageously used in sizes containing urea formaldehyde or other synthetic resins for improving the water resistance or wet scuff resistance of beer box liners and similar products. Subsequent waxing or other treatment to improve this feature may not then be necessary.

Penford Gums may be readily combined with various wax emulsions, proteins, latices, and polyvinyl alcohols or other synthetic or natural film formers for the sizing of paper or board to obtain a wide variety of finishes or effects for specialty uses.

Because the flow characteristics of the Penford Gums are so different from those of ordinary starches and because of the minimized gelling or set-back tendency Penford Gums frequently can be used at concentrations and viscosities materially higher than would be possible with the conventional starch sizes. This makes necessary a revision of the viscosity limits previously established for a particular use with regular starches.

The properties of the Penford Gums make them ideally suited for use as the adhesive for conventional on or off-machine paper coating colors. Their improved flow properties cause the colors to have good levelling properties and the minimized gelling or thickening tendencies of the starch contribute to good viscosity stability when the colors are aged. The good water-holding properties of the Penford Gums are responsible for decreased adhesive penetration into the body stock with a consequent decrease in the coating failures due to adhesive "starved" areas in the coating layer. The highly hydrated Penford Gums have excellent adhesive strength so that coatings made with them have uniformly high pick values.

The Penford Gum 280 and 380 are suited to many of the lower solids-type coating colors (up to 45% total solids) and the 3000 series Penford Gums are produced with viscosities that suit them for use in coating colors of up to 65 to 68% solids as required for many coaters.

The flow and filming properties of the Penford Gums ideally suit them for use as the adhesive portion of size-press coating colors and they have consequently been an important factor in promoting the use of such an application. With the Penford Gums it is possible to apply at the size-press a color having approximately the same pigment-starch ratio (up to 5 or 6) as that of conventional on or off-machine coatings and without the extreme patterning so noticeable when ordinary starches are used in this application.

Coating colors ranging from 15 to 45% total solids can be applied in this way with the resulting added coat weights ranging from 1 to 10 lb. per side per ream on sheets having a basis weight of from 30 to 90 lb.

Besides improving the brightness and opacity of the finished sheet a size press coating materially improves the smoothness and resulting printing properties. As a result, such sheets have been enthusiastically received and approved by many of the largest printing establishments in the United States and Canada.

Unfortunately, time does not permit detailed discussion of the application of Penford Gums as solid fiber adhesives and corrugating adhesives. Extensive work is being carried out however in both these fields at the present time and the results being obtained are very encouraging.

The work of our research and development departments also continues and, in addition to the Penford Gums already discussed which are already being consumed by the paper industry in substantial commercial quantities, new series of these products are being developed and additional technical data will be published as soon as it becomes available.

## Fibrous Filler—A New Pigment for the Paper Industry

*F. H. Denham*

An interesting new product in the pigment field, known as "Fibrous Filler," has been developed by the R. T. Vanderbilt Co., Inc. Paper mills in the United States and Canada are currently being licensed to make and use this product as a filler in paper and paperboard.

Because of its unusual properties and relatively low cost, as compared with the so-called high strength pigments, fibrous filler appears to have wide application in numerous grades of groundwood and chemical pulp papers.

A unique feature of this new pigment is that it has both organic and inorganic components. It consists of extremely fine hydrous calcium silicate particles precipitated on cellulose fiber. Perhaps partly because of this attachment to the fiber, the calcium silicate particles are highly retained in paper. These particles have an average diameter of only about 0.05 mu.

The mineral portion of fibrous filler is very bulky, weighing less than 7 lb. per cu. ft. compacted, is very white (TAPPI brightness 97 to 98), and is highly ink absorptive (ASTM oil absorption 150 grams oil per 100 grams pigment). Used as a

F. H. Denham, Technical Director, Paper Mill Dept., R. T. Vanderbilt Co., Inc., East Norwalk, Conn.

filler in paper, fibrous filler produces high brightness, good opacity because of the very large number of particles or reflecting surfaces, excellent surface smoothness, high ink receptivity, and increased bulk and resiliency, all of which add up to improved printing quality.

Fibrous filler is prepared in a paper mill under a license agreement with the R. T. Vanderbilt Co. Essential ingredients include pulp, calcium chloride, sodium silicate, and usually alum.

Almost any type of bleached or unbleached chemical pulp fiber may be used, and satisfactory fibrous filler has even been made with groundwood although generally this is not recommended. A low freeness processed stock such as deinked stock, broke, or waste paper also may be used advantageously in place of virgin fiber. The finished pigment is usually made to consist of 20% fiber and 80% calcium silicate, although this ratio may be varied if desired.

The fibrous filler is prepared by first processing the fiber in a calcium chloride solution and then adding a sodium silicate solution under conditions of rapid, high shear agitation so as to produce a very finely divided precipitate on the fiber. Usually an alum solution is then added, also under conditions of rapid agitation, to reduce the pH to neutral or slightly acid dependent upon the amount of alum used and the pH desired.

Attachment of the calcium silicate to the fiber is largely dependent upon the processing of the stock in the calcium chloride solution, maximum fibrillation being desirable. The calcium chloride has a softening or swelling effect on the fiber which tends to promote better filler attachment.

A fibrous filler production unit in a paper mill consists simply of a reaction tank, a refiner, means for supplying dilute sodium silicate and alum solutions, and storage tanks. When a low freeness processed stock such as deinked stock is used rather than virgin fiber, an ordinary stock pump may be substituted for the refiner. The reaction tank, which may be simply a wooden tank or almost any type of a stock chest, is piped so that stock may be fed from the bottom of the tank, through the refiner or the pump, and returned to the top of the tank. Small lines to handle the dilute sodium silicate and alum solutions are tapped into the inlet side of the refiner or pump.

In preparing fibrous filler, the required amount of slush stock is added to the reaction tank and then the dry calcium chloride is added. When virgin fiber is used, the suspension of stock in calcium chloride solution is cycled through the refiner and back into the reaction tank until the freeness is reduced to about 350 ml. Canadian. The fiber should be in contact with the calcium chloride solution for at least 30 min. If low freeness processed stock such as deinked stock or broke is used, the stock-calcium chloride solution is simply cycled through the pump for at least 30 min.

Then, while the stock is being circulated through the pump, or through the refiner with the plug backed off, a 10% sodium silicate solution is added through the line to the inlet side so that precipitation occurs under conditions of rapid high shear agitation. The volume of stock flow should be at least six times that of the sodium silicate solution flow.

After the required amount of sodium silicate has been added an alum solution usually is added in the same manner as the silicate solution to reduce the pH of the fibrous filler to the desired point, generally to about 4.5 to 5.0. The alum actually reacts with the pigment to form a complex hydrous calcium aluminum silicate.

The soluble salts formed as by-products of the reaction may be removed from the fibrous filler by washing on a rotary vacuum-type washer or by decantation. However, several mills now using fibrous filler without washing or decanting have experienced no trouble with production or quality due to these by-product salts.

As usually prepared, the fibrous filler slurry has a consistency of 0.6 to 0.7 lb. per gal. This is often metered, usually with a weir box, directly into the stock at the fan pump or some other point near the wet end of the machine. If preferable, the slurry may be added to the beaters with equal results.

The use of fibrous filler has been found advantageous in many grades of paper ranging from offset, bond, mimeo, and book to newsprint, and also in various grades of paperboard. Since the cost of this new pigment is only a fraction of the cost of so-called high strength pigments, fibrous filler frequently has been used to replace high strength pigments at a considerable saving. At the same time it has produced equal opacity and printed show-through, higher brightness, greater bulk, better surface smoothness, and greater ink receptivity.

It is used in tissue to improve softness and absorbency particularly when wet-strength resins are used.

Fibrous filler is used in coating rawstock as well as in uncoated papers. Addition of a small percentage to the rawstock of a coated magazine grade has permitted reduction in basis weight while maintaining good opacity, bulk, tearing strength and printing quality. The high brightness of the fibrous filler permitted substitution of unbleached for the bleached groundwood previously used in this rawstock.

The unusual properties of this new pigment promise a rapidly expanding use. Results to date have shown it to be an important addition to the list of products used as fillers by the paper industry.

***May Meeting***

The Western District of the Empire State Section of TAPPI climaxed their 1954–1955 season with its annual "Ladies Night," held May 5, 1955, at the Park Hotel in Lockport, N. Y., with about 80 members and guests and their wives attending. A buffet supper was followed by the election of officers for the 1955–1956 season.

The speaker of the evening was Ben Yaseen, Niagara Falls, N. Y., whose subject was "The Diamond—Universal Symbol of Sentiment." Dancing to the music of the "Mac Trio" completed a very enjoyable evening.

The Western District elected the following officers for the 1955–1956 season:

*Chairman*—James J. Forsythe, International Paper Co.
*Vice-Chairman*—Robert H. Zinsmeister, Kimberly Clark Corp.
*Secretary*—Leroy Lindberg, Robert Gair Co.
*Treasurer*—Ernest F. Andrews, International Paper Co.

Program Committee

*Chairman*—Harry B. Hulse, Upson Company
*Vice-Chairman*—Ward Arnold, International Paper Co.
*Vice-Chairman*—Robert Rosenbaum, Allied Chemical & Dye Corp.

Publicity Committee

*Chairman*—Oscar Anderson, Jr., International Paper Co.
*Vice-Chairman*—Donald Hagerla, Kimberly Clark Corp.

Arrangements Committee

*Chairman*—George Norton, George Irish Paper Co.
*Vice-Chairman*—Robert Driscoll, International Paper Co.

Attendance Committee

*Chairman*—Charles Raleigh, Buffalo Electro-Chemical Co.
*Vice-Chairman*—Fred Rosebush, Buffalo Electro-Chemical Co.

Membership Committee

*Chairman*—Gordon K. Storin, Niagara Alkali Co.
*Vice-Chairman*—Fred Heil, Lockport Felt Co.

O. E. Anderson, Jr.
*Publicity Chairman*

## *Pacific*

A joint meeting of Pacific Section of TAPPI; Pacific Coast Division, The American Pulp and Paper Mill Superintendents' Association; and The Pacific Coast Branch Technical Section Canadian Pulp and Paper Association, was held at Victoria, B. C., May 19–21, 1955. This was the annual meeting of

*F. E. Caskey, Morden Machines Co.; B. T. Briggs, Rayonier Inc.; and R. G. Macdonald, TAPPI*

the Pacific Section of TAPPI and the following new officers were elected:

*Chairman*—John M. McEwen, Weyerhaeuser Timber Co.
*Vice-Chairman*—Ben T. Briggs, Rayonier, Inc.
*Secretary-Treasurer*—Robert Smythe, Ray Smythe Co.
*Executive Committee*—H. B. (Pete) Petersen, Hercules Powder Co.; Kenneth Boothe, Crown Zellerbach; and Norval Magnusson, Puget Sound Pulp & Timber Co.
*Alternate* (for Ed Nunn)—S. P. Strayer, St. Regis Paper Co.

The technical program on Friday morning was sponsored by the Technical Section Canadian Pulp and Paper Association and the following four papers were presented at this meeting:

1. "Experimental Digester Studies on the High-Yield Sulphite Pulping of Hemlock," D. L. Stewart, Powell River Co., Ltd., Powell River, B. C.
2. "Operating Characteristics of the Elk Falls Vacuum Pickup," Jack Youden and Howard C. Graham, Elk Falls Co. Ltd., Duncan Bay, B. C.
3. "Making of a Fourdrinier Wire," by Arthur Leith, the Johnson Wire Works, Ltd., Montreal, Que.
4. Powell River Award Paper, to be presented by the winner of the award.

The afternoon of May 20 was devoted to mill visits at Sidney Roofing and Paper Co., Ltd., and British Columbia Forest Products, Ltd.

The men's golf tournament was also held the afternoon of May 20.

At 6:00 p.m. an informal cocktail party and a western buffet supper were held at the Crystal Gardens followed by an aquacade and dancing.

On May 21 the International Brotherhood of Migratory Peddlers, Waiting Room No. 2, sponsored a "Wake-em-Up" breakfast at which time they presented a charter to the British Columbia group of peddlers organized as a new Waiting Room.

The technical meeting was started at 9:00 a.m., and this meeting was sponsored by the Pacific Section of TAPPI with John M. McEwen acting as chairman. The following four papers were presented at this meeting:

1. "Crown Zellerbach Modernizes No. 2 Paper Machine at Port Townsend," Robert R. Marriott, Crown Zellerbach Corp., Port Townsend, Wash.
2. "Structural Fiber, a Pulp with Its Own Problems," Everett J. Reichman, Simpson Logging Co., Shelton, Wash.
3. "Continuous Chlorination of Bleach Liquor," Harry S. Fisher and Richard E. Carlson, Pennsylvania Salt Manufacturing Co. of Washington, Tacoma, Wash.
4. "The Effect of Paper on Color Changes of Meat," F. O. Whipple, Crown Zellerbach Corp., Camas, Wash.

The annual business meetings of the three associations were held at 11:00 a.m. followed by a men's luncheon at 12 noon. The Honorable Robert W. Bonner, Attorney General of British Columbia, spoke on the topic "Industrial Potential in Western Canada."

At 2:00 p.m. the same afternoon, the Pacific Coast Division Superintendents' Association sponsored a meeting at which the following four papers were presented:

1. "Bleached Groundwood in the Northwest," Harry Bamford, Westminster Paper Co., Ltd., New Westminster, B. C.
2. "Zinc Hydrosulphite Brightening of Groundwood," Vincent De Felice, Publishers' Paper Co., Oregon City, Ore.
3. "Breaker Stacks," H. R. Russell, Simpson Paper Co., Everett, Wash.
4. "Secondary Headboxes," Henry W. Dauterman, Longview Fibre Co., Longview, Wash.

At 6:00 p.m. a "Get-Together Party" honoring officers of the three associations and their wives was sponsored by the Industrial Affiliates and Allied Industries Committee. This was followed by a banquet at 7:00 p.m. with dancing until midnight.

This turned out to be the largest meeting of this type yet held on the Pacific Coast and the attendance figure was 596. Plans were initiated at this time for a similar meeting to be held 3 years from now.

## Crown Zellerbach Modernizes No. 2 Paper Machine at Port Townsend

*R. R. Marriott*

Since the 15th of May, 1929, which was the first day of production for Port Townsend's no. 2 machine, improvements have been continually made to increase speed and gain more production. The machine is a 248-in. right-hand Bagley & Sewall with a 251-in. Beloit removable fourdrinier. At the time of installation it had a Beloit wooden headbox, Beloit suction couch, one suction press, and two plain presses, one of which was a smoothing press. There were 44 main driers (60-in. diam.), one baby drier (48-in. diam.), and four felt driers (48-in. diam.). The reel (English type) and double drum winder were Bagley and Sewall.

This equipment, which at that time was the largest kraft machine in the world, was operated with minor improvements until 1934 on unbleached kraft paper for wrapping, cement bags, and grocery bags. During this year the wooden headbox began to disintegrate so it necessitated a replacement.

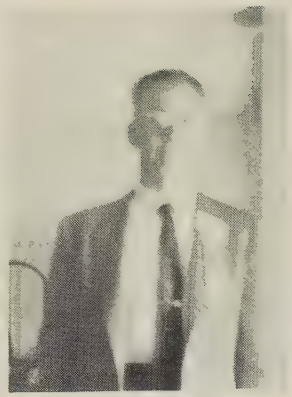
A cast-iron Beloit headbox with Voith slice and inlet were installed. Other significant changes were also made about this time which included a new braking generator on the winder to replace the mechanical brake. We discontinued the use of the smoothing press, installed a lump breaker roll, and put in a Ross-Grewin hot air system. These improvements increased production approximately 20% by 1936.

Improvements were continually being made, such as the removal of the smoothing press and the addition of four new 60-in. driers. Table rolls were replaced, changes and modifications of the vacuum system were accomplished, new drier gears were installed, four more felt driers were added, new flat boxes were installed, and numerous other changes were made. We managed to keep improving during the war years so by 1946 had increased our production from the 1929–30 average of 100 tons per day and a speed of 490 to 175 tons per day with an average speed of 875 f.p.m.

At this time it became apparent that we must adopt a new philosophy, one that we still uphold; "progress or decay."

R. R. Marriott, Technical Supervisor, Crown Zellerbach Corp., Port Townsend, Wash.

*J. M. McEwen, Weyerhaeuser Timber Co., Chairman, Pacific Section*



*B. T. Briggs, Rayonier, Inc.; Vice-Chairman, Pacific Section*

We had speeded up our machine as far as we could without a major rebuild. Our executives considered a major expenditure to rebuild and modernize our equipment but abandoned this plan for piece-meal improvements with the machine being brought up to higher speeds as rapidly as the changes warranted. Thus, we would be able to increase production by 100% (350 tons per day) and still operate the machine 7 days a week. The improvements would be made during the normal maintenance days with major changes scheduled for a minimum of down time.

This was a formidable undertaking; however, with the fullest cooperation of our engineering staff, maintenance crews, and paper machine crews, we began to expedite our modernization.

The first major contribution to increased production was the installation of three Morden refiners in May, 1949. The refining system at that time consisted of 12 beaters, three lines of four each for continuous beating. These were followed by six jordans in series of three. The Mordens were placed ahead of the beaters, one Morden serving each line of four beaters.

The next major capital expenditure was a Beloit pressure-type, stainless-steel lined headbox. Prior to the installation numerous changes were made in the electrical drives, improvements were made in drying, in the winder, felt conditioning, electrical regulation, and many others.

The new headbox was installed during the 4th of July shutdown in 1951. This headbox is an air-pressure type with a cross flow design. The slice is power operated. Preliminary work began a year before to make all the necessary piping changes and have the new fan pump ready to operate. The whole installation, which began with dismantling the old headbox and flow box was completed, with production resumed, in $4^1/_2$ days. This was accomplished by working our crews around the clock. The headbox was ready to run in $3^1/_2$ days; however, we had table rolls and deflectors to replace, a new forming board, and a new wire and felts to put on the machine.

The second suction press was also replaced this year. When this press arrived it was necessary to overhaul the press roll of the first press. We pulled the old roll and replaced it with the new second suction press roll. Later when repairs were completed we put in the new frames, air-loading equipment, a new top roll, and switched suction press rolls. It took 24 hr. for this job which was in excess of the original estimate. Unpredicted modifications were necessary during the installation.

During 1952 entrained air was found in the headbox. This circumstance was detrimental to the manufacture of a well-formed sheet. Determinations revealed that air was present in quantities large enough to hinder formation. Based on these determinations and reports of success in other mills, new recirculating piping was installed. We expected to get better mixing of stock and eliminate the air. Initial results showed only slight improvement so we had to raise the stuffbox and put in a plywood "bath tub" (deaerating dam) before we had satisfactory results.

During the 1952–53 fiscal year ending April 30, we installed a new first suction press as the old one had worn out and was incapable of operating at the higher speeds. We had by now learned how to operate the pressure headbox and with the new presses were able to increase daily production by 15 tons.

During the 1953–54 fiscal year additional vacuum pump capacity was added. Micarta drier gearing, improvements on the drive motors and gearing, and a replacement of the suction couch were also accomplished. The old couch was badly worn and speeds of 1250 were causing unsatisfactory vibrations.

In February a no. 3 Claflin, refiner with a hydrating shell liner was installed and used in place of four beaters. Quality was improved, production was increased, and power consumption for refining was reduced. Production for this fiscal year was increased 12 tons.

The refining system now bolstered by the Claflin was still inadequate for increased tonnage. A lava jordan was installed for trials in June of 1954. This was a standard size jordan with a lava stone plug and a cast-iron shell with 28 bars at the small end splitting to 56 bars at the midpoint. A Bidwell shell liner was later installed.

Results of the trials showed that the lava jordan had less strength development than the Claflin but slightly more than the beaters. The major disadvantage of the jordan was the pitting and spalling of the lava sections. We are now preparing to put in a plug with standard tackle and make further trials.

Based on the results of the first Claflin two more were installed in 1955 to replace all the beaters. The quality of the Claflin refined stock enabled us to run with higher jordan freeness and better drainage on the machine. This installation aided in attaining increased speed and production.

As production increased stock pumps had to be replaced. New pumps have been installed throughout the paper mill.

The 1954–55 fiscal year which has just been completed has included wire pit alterations, fan pump piping changes to deaerate stock, a booster generator, 10 high-pressure driers, a draw control, a new Beloit winder and roll handling system including a lowerator, additional exhaust fans and vents, new high-pressure steam line to the driers, and other changes which were minor.

The wire pit alterations were completed last 4th of July. We had reached speeds in excess of 1400 f.p.m. but had stock level variations in the headbox that prevented any further increases. The pit was tile lined, the sump to the fan pump was enlarged, and the plywood deaerating dam was replaced with one of concrete and tile. These changes helped reduce the air and foam and also made it possible to increase our wire pit temperatures. We were unable to do it with the concrete pit.

Ten new high-pressure driers were also installed during this shutdown. In this installation as in the others the work was carefully planned. In order to keep the machine operating with a minimum of downtime, we spent several months going over every detail of the job.

The engineers and foremen had meetings with the men who were to do the work. A schedule was set up and each man knew exactly what he was going to do and why. The hazards and safety precautions were covered in detail. Interest in the job was at a high level when we started removing the hood on July 3rd. We split the crew in two and worked 12 hr. a shift. Many of the men kept asking if they were on schedule. The job was completed in 72 hr. and the only injury was a pipe fitter's burned wrist.

Considerable down time was saved by the use of special drilling jigs which were made in the shop. They were used on

the machine frame for the anchoring of the bearings. Time was also saved by preliminary bracing of the machine hood and the use of special beams and legs which allowed the whole section of hood to be removed and replaced in one piece.

The new Beloit winder has just been put into continuous operation. We made our first trial the 20th of last month, and after training the crews to operate it have discontinued using the old winder. It is now being dismantled and removed.

This installation necessitated extending the machine room so we could install the new winder while still using the old one. A concrete floor was poured over the roll pit for the winder and all the auxiliary equipment. Included were a mechanical shaft puller and levelator. These reduced the manual labor of the machine crew.

The new winder has a speed of 4500 r.p.m. compared to the old one of 3300. We have been able to increase our throughput and improve roll quality. The old winder had no rider roll and had to start slowly to make good rolls. Consequently it was difficult to keep up with machine production. It was also 100% overloaded on the motors during the acceleration period. Individual slitter motors and capacity to make 60-in. diam. rolls are also advantages of the new winder.

The lowerator was added to the outside of the building adjacent to the winder. This facilitated roll handling by delivering rolls in the shipping area without the previous long haul through the mill and down an elevator.

This brings us up to date as of May, 1955, so that with the modernization thus far completed and the complete and efficacious cooperation of the "snoose" chewing, bragging, evergriping machine crews, we have increased daily average production 30 tons over the previous year. This gives us a daily average of 265 tons and speed of 1315 which is an increase of 51.5% over our 1946 average.

Our goal is still 350 tons average daily production with maximum speeds of 1800 f.p.m.; however, we have made a record run of 346 tons for one day. To reach this goal our plans include a magnetic amplifier speed control, increased water vapor removal, new table rolls, a new reel, Feeney felt driers, modernization of staring equipment for motor generator sets, additional driers and hot air to the machine, a saveall to enable us to effectively heat our machine stock, furnish and save water and fiber, and to improve quality and reduce paper breaks, we are considering the installation of Centri-cleaners.

At the present time we are limited to a maximum speed of 1560 f.p.m. until the magnetic amplifier speed control is installed. We plan to start the first step of this installation in the near future. It will consist of changing the gear ratios on the section drives. We will then be able to increase speeds on our light weight grades.

## Structural Fiber—A Pulp with Its Own Problems

*E. J. Reichman*

Structural fiber is mechanically separated cellulosic material that is processed to produce various properties that are desired in numerous phases of the building industry. The products may be classified as hardboard, semihardboard, or insulation board, according to the density range of the finished material. Most manufacturing operations employ water-borne suspensions of fibers for processing and formation. This phase of the operation is comparable to pulp and paper manufacturing but there the similarities end. Pulping and processing to produce desired structural properties create problems that are peculiar to the industry and mark structural fiber as a different pulp in its own right.

The similarity of the process to papermaking has led to the use of some modifications of pulp machinery and a tendency

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*Robert Smythe, Ray Smythe Co., Secretary-Treasurer, Pacific Section*

*Norval Magnusson, Puget Sound Pulp & Timber Co.; Executive Committee, Pacific Section*

to copy paper testing procedures and control methods. The results have not been entirely satisfactory. There are several areas where plant and product improvements might be made by a better understanding of the basic nature of the pulp.

The application of paper tests to structural fiber is wholly unsatisfactory for two reasons: first, the pulp makes very poor paper with correspondingly low paper strength values; second, interpretation of the results depends upon correlation curves between paper and structural properties. The relationship of the two is open to question. In 1951 a tentative TAPPI standard for test board formation was drafted by the Structural Fibrous Materials Committee. The basis for this approach to evaluating structural pulps was quite logical. Papermaking qualities of a pulp are determined by conducting paper strength tests on laboratory-made sheets of paper. The situation for insulating board pulps is analogous; since structural strength values are sought, the laboratory test specimen should resemble its manufactured counterpart and be of sufficient size for actual testing. In our laboratory we have followed this practice since the first day that a structural fiber was experimentally produced. TAPPI standards now include T 1001 sm-51 for the formation of structural test boards.

Control of stock furnish in an insulation board plant is not a simple problem. The raw material is extremely variable by nature and these irregularites are transferred almost 100% into the stock. Because all of the wood is utilized, there is no elimination of part of the wood by cooking, or any chance for cooking control. A battery of pulpers may add additional variations and in many instances more than one type of pulpers are used. The stock system capacities are small by comparison to pulp mills and changes can occur in short periods of time. In some mills there is no secondary refining to assist in final control. Freeness testers have been the only practical means of measuring stock refinement for control purposes. Drainage testers that were originally designed for paper stocks have been copied, altered, or otherwise adapted for testing of insulation board stocks. The performance has not been all that could be desired.

A drainage time tester designed to measure insulation board stocks has been developed by the TAPPI Structural Fibrous Materials Committee. Two instruments have been built for critical examination by the different insulation board manufacturers. The operational characteristics of the SFMC tester, including a study of several variables, has been reported (*1*) and the experience of 2 years' use in control work was related at the annual TAPPI meeting (*2*). These reports were very favorable but several factors relating to our own operations were not answered. We have made a study of the operation and have some additional information to add regarding its operating qualifications.

Critical variables in the operation of a freeness tester, such

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*F. O. Whipple, Crown Zellerbach Corp.*

as quantity of stock, pH, and temperature, are closely regulated by standardization of control procedures. For complete confidence in a testing apparatus an operator must also know the inherent variability of the instrument on all types of stock, how much variance is likely to exist between the different control men, and how sensitive is the equipment to differences in stock.

## METHOD OF TESTING THE SFMC DRAINAGE TIME TESTER

The SFMC tester was compared with the Green modification of the Canadian Standard freeness tester that has been used for control for some time. Four operators ran four tests on each of three pulps with both instruments. The pulp samples represented the two extremes used in the mill plus a third stock of intermediate refinement that is used for blending purposes. The operators were persons well trained in the use of testing equipment, but only one had previous experience with the SFMC tester. The pulp stocks were drained and pressed to partial dryness and multiple moisture determinations were made. All samples were weighed out by one person on a balance with a sensitivity of 0.05 gram. The samples were all stirred for 5 min. at 1.5% consistency, using the same laboratory mixer. The use of laboratory tap water assured consistent conditions of pH and temperature and the drainage pads were saved, dried, and weighed to be certain that irregular stock quantities did not enter into the results. The SFMC tester requires 10.6 grams of dry stock and our method of using the Canadian Standard requires 10 grams. The amount of stock should be very close to the specified quantity and on any given pulp sample all operators should have samples as close to the same weight as practical.

The application of statistical analysis to the data permits a good evaluation of the instruments with relatively few samples. The data collected from the tests are listed in Table I.

A comparison of the range of values obtained by the two instruments shows immediately an advantage of the SFMC tester for these types of stock. The drainage time tester has multiplied the range by a factor of approximately 8 thereby providing a sound basis for better measurement of differences between stocks. Where stock 2 showed a 50% increased value over stock 1 on the Canadian Standard machine, the SFMC tester shows almost a fourfold difference, and where the difference between pulps 2 and 3 is approximately 25% on the Canadian Standard, the SFMC shows a difference of 5 times. Experience has shown that the readings for pulp no. 3 are near the maximum obtainable with 10 grams of pulp in

**Table I**

| Pulp | Operator A | | Operator B | | Operator C | | Operator D | |
|---|---|---|---|---|---|---|---|---|
| | Freeness, ml. or sec. | Pad wt., g. | Freeness, ml. or sec. | Pad wt., g. | Freeness, ml. or sec. | Pad wt., g. | Freeness, ml. or sec. | Pad wt., g. |
| | Tester—Green Modification of Canadian Standard | | | | | | | |
| 1 | 270 | 10.05 | 305 | 10.1 | 300 | 9.85 | 310 | 10.15 |
| | 300 | 10.0 | 310 | 10.15 | 307 | 10.2 | 290 | 9.95 |
| | 310 | 10.0 | 300 | 9.95 | 300 | 10.0 | 295 | 10.1 |
| | 305 | 10.05 | 310 | 10.1 | 262 | 10.1 | 315 | 10.15 |
| | Av. 296 | 10.03 | 306 | 10.08 | 292 | 10.04 | 303 | 10.09 |
| 2 | 435 | 9.85 | 445 | 9.95 | 450 | 10.15 | 430 | 9.85 |
| | 460 | 9.95 | 450 | 10.1 | 465 | 9.95 | 445 | 10.0 |
| | 465 | 9.75 | 450 | 9.8 | 452 | 9.9 | 445 | 10.0 |
| | 455 | 10.15 | 445 | 9.8 | 475 | 10.1 | 450 | 9.8 |
| | Av. 454 | 9.93 | 447.5 | 9.91 | 460.5 | 10.03 | 442.5 | 9.91 |
| 3 | 575 | 9.4 | 560 | 9.3 | 555 | 9.6 | 565 | 9.5 |
| | 565 | 9.55 | 560 | 9.55 | 540 | 9.55 | 525 | 9.7 |
| | 560 | 9.35 | 565 | 9.3 | 560 | 9.8 | 545 | 9.65 |
| | 570 | 9.4 | 550 | 9.25 | 555 | 9.7 | 560 | 9.5 |
| | Av. 568 | 9.43 | 559 | 9.35 | 553 | 9.66 | 549 | 9.61 |
| | TAPPI-SFMC Drainage Time Tester | | | | | | | |
| 1 | 146.5 | 10.55 | 154 | 10.35 | 117.8 | 10.6 | 140.2 | 10.7 |
| | 146.5 | 10.7 | 178.7 | 10.4 | 116.7 | 10.65 | 152.8 | 10.8 |
| | 138.2 | 10.6 | 136.3 | 10.8 | 127.5 | 10.7 | 144.4 | 10.55 |
| | 146.5 | 10.65 | 147.3 | 10.3 | 126.3 | 10.7 | 156.6 | 10.6 |
| | Av. 144.4 | 10.63 | 154.1 | 10.46 | 122.1 | 10.66 | 148.5 | 10.66 |
| 2 | 40.5 | 10.7 | 41.6 | 10.5 | 35.7 | 10.5 | 40.4 | 10.55 |
| | 39.2 | 10.7 | 44.2 | 10.75 | 41.2 | 10.65 | 42.4 | 10.7 |
| | 43.2 | 10.8 | 44.4 | 10.55 | 42.5 | 10.75 | 39.2 | 10.55 |
| | 39.0 | 10.6 | 44.5 | 10.7 | 42.6 | 10.45 | 40.8 | 10.55 |
| | Av. 40.5 | 10.7 | 44.4 | 10.63 | 40.5 | 10.59 | 40.7 | 10.59 |
| 3 | 7.7 | 10.05 | 8.3 | 10.2 | 8.0 | 10.5 | 7.6 | 10.15 |
| | 7.9 | 10.1 | 8.4 | 10.4 | 8.0 | 10.4 | 7.8 | 10.25 |
| | 7.9 | 10.35 | 8.0 | 10.5 | 8.2 | 10.3 | 7.6 | 10.55 |
| | 7.5 | 10.1 | 8.4 | 10.45 | 7.8 | 10.7 | 8.1 | 10.4 |
| | Av. 7.8 | 10.15 | 8.3 | 10.39 | 8.0 | 10.48 | 7.8 | 10.34 |

the Canadian Standard, even if the pulp is made up of shives and match sticks, whereas the SFMC is capable of accurate measurements as low as 2 sec.

The first question arising from a study of the data is whether or not the variations in freeness values were caused by differences in pad weights. A plot of the freeness values versus pad weights shows no indication of correlation. The tests of pulp no. 3 on the SFMC tester give the greatest indication of a correlation between pad weight and freeness but a calculation of a correlation coefficient proved that no significant correlation existed, therefore the freeness variations cannot be attributed to different amounts of pulp stock.

The next question to be answered is whether or not a significant difference exists between operators. This can best be measured by a statistical evaluation called "Students' $st$" test.

| *D* | *A* | *B* | *C* |
|---|---|---|---|
| 310 | −40 | −5 | −10 |
| 290 | 10 | 20 | 17 |
| 295 | 15 | 5 | 5 |
| 315 | −10 | −5 | −53 |
| 430 | 5 | 15 | 20 |
| 445 | 15 | 5 | 20 |
| 445 | 20 | 5 | 7 |
| 450 | 5 | −5 | 25 |
| 565 | 10 | −5 | −10 |
| 525 | 40 | 35 | 15 |
| 545 | 15 | 20 | 15 |
| 560 | 10 | −10 | −5 |
| Total | 95 | 75 | 46 |
| Average of difference | | | 7.91 |
| Sum of the squares of differences | | | 4725 |
| Sum of differences$^2/n$ | | | 752.83 |
| Difference | | | 3972.17 |
| Variance | | | 361.106 |
| Standard deviation | | | 19.00 |
| Standard deviation of mean | | | 5.49 |

$$t = \frac{\text{Average difference}}{\text{Standard deviation of the mean}} = \frac{7.91}{5.49} = 1.44$$

On the Canadian Standard tester, operator D showed a tendency toward lower readings, therefore, the other operators should be compared to him. Since we are only testing for a difference, we can write down the algebraic difference on each reading for the other operators.

Statistical tables tell us that one time in five we may expect differences as large or larger than those between operators A and D due to chance in sampling. Since the differences between D and the other two operators are even smaller, we can safely assume that there is no significant operator difference shown in the use of the Canadian Standard machine.

The data for the SFMC tester show operator C to have lowest average results, therefore, the same test will be made to compare the other operators to C. Here again we can work with algebraic differences and thus simplify the calculation.

| *Actual, C* | *Difference* A | B | D |
|---|---|---|---|
| 117.8 | 28.7 | 36.2 | 22.4 |
| 116.7 | 29.8 | 62 | 36.1 |
| 127.5 | 10.7 | 8.8 | 16.9 |
| 126.3 | 20.2 | 21.0 | 30.3 |
| 35.7 | 4.8 | 8.9 | 4.7 |
| 41.2 | −2.0 | 3.3 | 1.2 |
| 42.5 | 0.7 | 1.9 | −3.3 |
| 42.6 | −3.6 | 1.9 | −1.8 |
| 8.0 | −0.3 | 0.3 | −0.4 |
| 8.0 | −0.1 | 0.4 | −0.2 |
| 8.2 | −0.3 | −0.2 | −0.6 |
| 7.8 | −0.3 | 0.6 | 0.3 |
| | 88.3 | 144.8 | 105.6 |
| Average difference | 7.36 | 12.4 | 9.03 |
| (Sum of differences)$^2$ | 2275.03 | 5768.96 | 3046.98 |
| Sum squared ÷ number | 649.74 | 1747.25 | 929.28 |
| Difference | 1625.29 | 4021.71 | 2117.70 |
| Variance | 147.7536 | 365.61 | 192.5182 |
| Standard deviation | 12.155 | 19.12 | 13.875 |
| Standard deviation of the mean | 3.52 | 5.54 | 4.01 |
| | 2.09 | 2.24 | 2.25 |

$t$ value of 11 degrees of freedom and 0.05 probability = 2.20

The $t$ values show that there is less than one chance in 20 that the differences as large as those between C and B or D could be due to chance of sampling, and that there is less than one chance in ten that sampling accounted for the difference between C and A. We can, therefore, conclude that C is prone to getting lower results than the other operators.

Operator B showed an inclination to higher values than the other operators, therefore, we should make the same test for a difference between B and A and D.

| *Actual B* | *Difference* A | D |
|---|---|---|
| 154 | −7.5 | −13 8 |
| 178.7 | −32.2 | −25.9 |
| 136.3 | +1.9 | +8.1 |
| 147.3 | −0.8 | +9.3 |
| 44.6 | −4.1 | −4.2 |
| 44.2 | −5.0 | −1.8 |
| 44.4 | −1.2 | −5.2 |
| 44.5 | −5.5 | −3.7 |
| 8.3 | −0.6 | −0.7 |
| 8.4 | −0.5 | −0.6 |
| 8.0 | −0.1 | −0 4 |
| 8.4 | −0.9 | −0.3 |
| Sum of difference | −58.4 | −56.6 |
| Average difference | −4.87 | −4.72 |
| Sum of squares of differences | 1172.27 | 1076.06 |
| (Sum of differences)$^2$ ÷ $n$ | 284.21 | 266.92 |
| Difference | 888.06 | 809.10 |
| Variance | 80.7327 | 73.5545 |
| Standard deviation | 8.985 | 8.576 |
| Standard deviation of the mean | 2.59 | 2.48 |
| | 1.88 | 1.90 |

Significance is between the 5 and 10% level, but a genuine difference has not been shown.

The $t$ values are almost large enough to prove a difference between B and the other two operators, but there is still almost one chance in ten that the difference was due to sampling.

The fact that we have shown a difference between operators is no discredit to the SFMC tester; operator variance can be reduced by standardization of techniques and by experience. It is important that the tester is sensitive enough to measure variability between operators.

The next step in the investigation is to pool the measurements on each tester for the three pulps in turn, and by an analysis of variance study, determine the amount of operator variance and the variance due to stock and tester. Since we are interested in measuring variations, it is permissible to subtract a constant from each reading and thereby simplify the arithmetic.

Table III summarizes the findings about the two testers on each of the three pulp stocks.

The superiority of the SFMC tester increases on the faster draining stocks. The accuracy of both the operators and the machine improves as the drainage time is reduced, whereas the confidence limits for the Canadian Standard remain approximately the same. The data do not provide for a separation of machine and stock variance, but inasmuch as they are combined in practice, knowledge of machine variance would be largely academic.

The SFMC tester accomplishes the purpose for which it was developed. The range of freeness values on insulation board stock has been greatly expanded and the accuracy of the instrument is best on the stocks that are difficult to evaluate

**Table II. Analysis of Variance (3)**

| Source of variance | Pulp no. | Canadian standard: Sum of squares | D. F. | Mean squares | SFMC tester: Sum of squares | D. F. | Mean squares |
|---|---|---|---|---|---|---|---|
| 4 X operators, plus stock and machine | 1 | 470.19 | 3 | 156.73 | 2362.62 | 3 | 787.54 |
| Machine and stock | | 2715.25 | 12 | 226.27 | 1284.16 | 12 | 107.01 |
| Total | | 3185.44 | 15 | 212.36 | 3646.78 | 15 | ... |
| Variance ratio | | | 0.69 | | | 7.33 | |
| Significance level | | | Not significant | | | 1% | |
| Operator variance | | | Indeterminable | | | 170.13 | |
| Total variance | | | 212.36 | | | 277.14 | |
| Total standard deviation | | | 14.6 | | | 16.6 | |
| Standard deviation of machine and stock | | | ... | | | 10.35 | |
| 95% confidence limits for an average of four observations | | | 14.6 | | | 16.6 | |
| 95% probability limits for one reading | | | 29.2 ml. | | | 33.2 sec. | |
| 4 X operators, plus stock and machine | 2 | 729.19 | 3 | 243.06 | 44.975 | 3 | 14.991 |
| Machine and stock | | 1181.75 | 12 | 98.48 | 48.495 | 12 | 4.041 |
| Total | | 1910.94 | 15 | 127.40 | 93.47 | 15 | ... |
| Variance ratio | | | 2.48 | | | 3.70 | |
| Significance level | | | 10% | | | 5%+ | |
| Operator variance | | | 36.14 | | | 2.737 | |
| Total variance | | | 163.54 | | | 6.778 | |
| Total standard deviation | | | 12.7 | | | 2.43 | |
| Standard deviation of machine and stock | | | 11.3 | | | 2.01 | |
| 95% confidence limits for an average of four observations | | | ±13.0 | | | 2.4 | |
| 95% probability limits for one reading | | | ±25 ml. | | | ±4.9 sec. | |
| 4 X operators, plus stock and machine | 3 | 806.25 | 3 | 268.75 | 0.715 | 3 | 0.2383 |
| Machine and stock | | 1437.5 | 12 | 119.79 | 0.465 | 12 | $0.0387^5$ |
| Total | | 2243.75 | 15 | 149.58 | 1.18 | 15 | 0.7866 |
| Variance ratio | | | 2.25 | | | 6.15 | |
| Significance level | | | 10% | | | 1% | |
| Operator variance | | | 37.24 | | | 0.0499 | |
| Total variance | | | 157.03 | | | 0.0886 | |
| Total standard deviation | | | 12.5 | | | 0.297 | |
| Standard deviation of machine and stock | | | 10.9 | | | 0.197 | |
| 95% confidence limits for an average of four observations | | | ±12.5 | | | ±0.3 | |
| 95% probability limits for one reading | | | ±25 ml. | | | ±0.6 sec. | |

**Table III**

| | Canadian standard: Pulp 1 | Pulp 2 | Pulp 3 | TAPPI-SFMC tester: Pulp 1 | Pulp 2 | Pulp 3 |
|---|---|---|---|---|---|---|
| Average freeness value | 299.4 | 451.1 | 556.9 | 142.2 | 41.5 | 7.95 |
| 95% confidence limits of average | ±7.8 | ±6.8 | ±6.4 | ±8.9 | ±1.3 | ±0.16 |
| 95% probability limits for one observation | ±29 | ±25 | ±25 | ±33.2 | ±4.8 | ±0.6 |
| 95% confidence limits for average of four observations | ±15 | ±13 | ±12.5 | ±16.6 | ±2.4 | ±0.3 |
| 95% probability limits for one observation with no operator variance | ±29 | ±23 | ±22 | ±20.7 | ±4.0 | ±0.4 |

on the Canadian Standard tester. The TAPPI-SFMC drainage time tester is a good example of the benefits the insulation and hardboard industry can derive from having structural fiber considered as a pulp with its own problems.

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## Continuous Chlorination of Bleach Liquor (Abstract)


*Harry S. Fisher and Richard E. Carlson*



CONTINUOUS production of bleach liquor offers many advantages. A satisfactory method of controlling chlorination of the lime or soda base used, coupled with known methods for the control of the alkali strength and accepted procedures for clarification, makes such operation practical.

Automatic control of chlorination utilizing the oxidation-reduction potential as the measured variable is demonstrated at variable flow rates, available chlorine contents, excess alkali concentrations and for both soda and lime. Control limits, variables, and instrumentation are discussed. An operating flow diagram is presented.


## Effect of Paper on Color Changes of Meat (Abstract)


*Francis O. Whipple*



THE color changes that occur in meat on aging and the effects of various materials in contact with the meat on these color changes are important to the manufacturer of butcher paper and plattering board. Spectrophotometric reflectance measurements in the visible range made directly on the meat provided a satisfactory means of detecting and recording these color changes. Reduced hemoglobin, oxyhemoglobin, and methemoglobin, the principal pigments whose presence determines the color of meat under various conditions, were easily detected by their characteristic absorptions. Reflectance measurements indicated the general course of the oxidative changes undergone by the meat pigment, hemoglobin, and provided a simple, direct means of observing the effect of various materials in contact with meat on its color as a function of time.

## *Chesapeake and Allegheny Pulp and Paper Club*

The following paper was presented at the March meeting of the Chesapeake and Allegheny Paper Club.

### Modern Printing Inks

*William T. Diefenbach*

DEMAND for more speed in printing, but still improvement in the quality of printed matter, has brought about processes based on newer methods of drying the ink films. Accommodation to these processes has necessitated the development of such ink types as heat-setting, moisture-setting, and plastisols. Paper and board stocks have been developed to meet the printing conditions. Ink and paper have to be especially designed for each other.

To the layman, printing ink is singular. It is a material that can be used to print paper, plastic, cloth, or other material. Actually there are many types of printing inks with wide variation in composition. Each type has within itself inks varying according to the material they are to imprint, and in other ways, such as speed at which they are to be printed and their method of drying. It is not intended to list here all the types, but consideration shall be given to a few to illustrate the trend in modern printing inks.

The largest tonnage of ink is sold for printing newspapers. These inks consist chiefly of carbon black ground in mineral oils with a little asphaltum or rosin added to increase tack or flow. Formerly, they were toned bluish by dye bases dissolved in oleic acid. Today, dye has been discontinued and toning is accomplished by the substitution of blue toned "furnace" carbon black for part of the brownish "channel" carbon black which was formerly used exclusively.

Colored news inks, for comics or pulp magazines, were formerly made by grinding pigments into mineral oils which might, or might not, contain small amounts of drying oils or resins, such as ester gum, to brighten them and hold them more firmly to the sheet. Today, the freshly made pigments are "flushed" directly from the water wet state in which they are made into oil dispersion without drying or grinding. This eliminates at least two steps, reduces cost, and increases pigment color strength in the ink.

For years the mass of printing has been done from raised type, using inks having linseed oil vehicles. During World War II, there was a great shortage of this oil and a search for substitutes was made. The combination of linseed oil shortage, economy, and research produced marvels. Today, the use of soybean and fish oils has increased enormously at the expense of linseed. These oils had dried slower and produced softer films. They are now upgraded, for example by treatment with maleic anhydride, and can be made equal or superior to linseed oil. Synthetic drying oils have even been made from originally nondrying castor or mineral oils. Faster setting of oil-based inks is now also accomplished by the incorporation of gel compounds which aid to reduce offset. For years waxes have been used in ink formulas to "top" the ink film, reduce offset, and increase rub resistance. Waxes are still used, but microcrystalline and harder waxes have been substituted in many cases. Lately means have been found to incorporate relatively high molecular weight polyethylene into oil inks. As the ink dries this produces a dry, smooth, highly scratch-resistant surface on the ink film, which greatly reduces offset and increases scuff resistance. Better and better synthetic resins have been developed which give desirable properties to ink films, such as hardness, fast drying, gloss, and rub resistance.

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The biggest change in lithographic offset printing has probably been in the printing equipment. Until recently printing was done almost solely from zinc or aluminum plates. These plates, however, have relatively short lives because of the softness of the metal. They are unsuitable for long press runs of planeographic lithographic inks. Now new bi and trimetallic plates have been produced. With the hard chromium surface, these plates may be good for over 1,000,000 impressions before wear shows. Some presses are now equipped with heaters so that it is possible to print and dry four-color offset in the web at over 800 f.p.m. Long runs at increased speed are possible because of the heating units and the new plates. Mail order catalogs are now printed offset in this manner. Lately, considerable success has been obtained in increasing finish in lithographic offset prints by applying the heat set principle to offset ink formulation. Paper for these presses is still a problem as it must stand water from the damping rollers and then later high temperature drying.

Gravure printing is done by printing with soft or thin inks from intaglio plates. Originally, the ink solvent used was a coal tar solvent, such as xylol, while the resin was gilsonite. This gave the brown gravure section in the Sunday papers. Long since, other solvents and resins have been substituted, although gilsonite is still used to some extent. Today's cheapest colored gravure inks contain metallic resinates dissolved in mineral oil fractions. Some better grades have improved properties such as faster drying and more rub resistance. These may contain nitrocellulose, ethyl cellulose, or vinyl resins. Today, the field for this ink has broadened greatly and includes magazines (e.g., *Seventeen*) newspapers, comics, and textiles.

One of the fastest growing types of printing is done with flexographic, formerly called aniline, inks. These were called aniline inks because they contained dyes, and years ago synthetic dyes were called "aniline dyes" since so many of them were derived from aniline. These inks originally contained dyes dissolved in a vehicle of shellac dissolved in alcohol. Today, they are made from varied, mostly synthetic, resins although much shellac is still used. Many organic solvents have been added to the alcohol once used solely. Dyes are still used in many of these inks, but a high percentage now contain pigments. Printing has generally been done from typographic plates. These have been mostly rubber, but some metal is used. Flexographic inks are thin in body. They do not print very well from screens, although some attempts have been made along this line. Consequently, they are used where printing of solids and lines is sufficient. Flexographic printing can be used on a great variety of materials—from cellophane through paper. It is used for printing many types of wrappings including those for candy and food. It is also used for printing box linings or covers, and lately in large volume for cartons.

The latest type of ink to be developed is the plastisol type, containing polyvinyl chloride resin. This ink dries instantly on a heat treatment of the printed film, due to the resin swelling and absorbing the oil vehicle that was used to plasticize it. This ink film has excellent rub resistance but is difficult to remove from paper in a "deinking process," as it does not saponify.

One of the biggest changes in printing processes in the last 25 years has been the development of the heat-setting printing process and of the inks and paper for it. The volume of printing done by the heat-setting process is now enormous, because of its economy and effectiveness. It accomplishes terrifically fast printing of good quality and is suitable for long runs. One large publication alone uses approximately 3,000,000 lb. of this ink a year in four colors. The ink used is colored by pigments. The vehicle is preferably a pseudo-soluble resin in close-cut petroleum fractions. Because of pseudosolubility, the solvent retention of the resin is low and drying of the ink rapid, especially with the heat treatment of

the printed film. Ink compounds are included to "top" and harden the printed film, greatly reducing offset which has been a problem at the terrific press speeds used. In 1947 printing was done by the heat-set process in four colors at about 900 f.p.m. By 1951 this printing could be done at 1500 f.p.m. and the quality, if anything, improved. Now a new press is being built to print at 2000 f.p.m. The heat-set process used in such high-speed publication printing imposes heavy demands on the paper used. Heating of the ink film on paper has been accomplished in different ways. In one method, flames were momentarily impinged on the moving printed web to heat it to a point where some ink solvent would penetrate the paper and the bulk volatilize off to be flashed or burned. Press attachments automatically shut off the flames as the press slowed down or stopped. Today, in many cases heat is given to the web from white hot ceramic cups, and the paper is automatically lifted from the hot zone on press slow downs. Sometimes the printed web is passed over steam heated drums at about 325°F., or subjected to jets of air heated up to 650°F. Attempts are usually made to keep the drying temperatures at around 300°F. web temperature, but occasionally in multicolor work, where a web has a heavy film, a web temperature of 400°F. has been reached for a few seconds. The heating contact is only long enough to get rid of the solvent so as to dry the ink. Directly thereafter practically instant cooling of the web is effected by use of chilling rollers. Paper for such printing must satisfactorily withstand these operations without scorching, brittling, disfiguring, or significant loss of strength, which might cause costly web breaks. Heat resistivity should be considered in designing a stock for such work. The stock should not be too thin and must stand high heats. Because of the fast printing rate, the paper stock should be considerably more pick resistant than that used for slower moving webs.

Less than 20 years ago, a new and novel way of making inks dry was invented. With glycols as solvent instead of oils, the inks printed like oil inks but when the printed film was diluted with moisture from the paper, or from an imposed jet of steam, the glycol diluted and the resin and pigment precipitated dry upon the paper. This precipitated film, not being oil soluble, would not bleed into hot wax or oil so was ideal for printing all types of materials to be hot waxed. Today, over $7,000,000 worth of this ink is sold each year. The paper used must stand wetting with glycol and moisture without seriously weakening the web. In some cases, the paper must also stand heat as for faster printing steam jets up to 700°F. have been directed at the printed web. However, with much of the printing, especially of bread wrappers, the moisture already in the paper is sufficient to precipitate the pigment for drying of the film.

In spite of the great advances in modern printing methods and materials, research and new innovations continue. Cooperative work between ink, paper, and press manufacturers continues. Some work is being done on paper development, which aim is to accomplish faster ink setting on paper by "paper-ink reactions." A press manufacturer and a large publishing concern are developing a new press to print at 2000 f.p.m. Mr. Gessler of Interchemical Corp., creator of the heat-set printing process, now has perfected a new ink drying process which should find its way into industry shortly. Work on dry offset is proceeding well. As in other fields, there seems to be no end, and it seems safe to prophesy that the developments in the next few years will be as spectacular as those in the past 20.

The problems of the newer printing processes, and of those most surely soon to come, are no longer ink or paper problems. More than ever, they are mutual problems of the manufacturers of ink and paper, the engineer and the printer. Teamwork and cooperation has become absolutely necessary to continue the wonderful developments which are taking place in the field of graphic arts.

## *Southeastern*

The Southeastern Section of TAPPI held its final meeting of the 1954–55 program year at the Hotel DeSoto, Savannah, Ga., May 13, 1955.

About 190 members and guests were present for the social hour, dinner, and evening technical session.

Mr. Pineo, completing his second year as section chairman, introduced J. R. Lientz of Union Bag & Paper Corp. who welcomed the group on behalf of the host mill.

Mr. Lientz extended Union Bag's invitation to visit the mill Saturday morning and described briefly some of the things of probable interest in their mill operations.

The slate of officers for next year was presented by Mr. Lientz, chairman of the nominating committee. The following officers were then elected or appointed:

C. N. Rogers, *Chairman*
W. C. Chapman, *Vice Chairman*
R. R. Chase, *Program Chairman*
Roy Homans, *Corresponding Secretary*
W. M. Ackerman, *Local Arrangements Chairman*
C. L. Smith, *Recording Secretary*

Mr. Pineo turned the meeting over to W. C. Chapman, program chairman, who presided during the technical session. Four prepared papers were presented.

Noel R. Phillips gave a very interesting paper on "The Effect of Hurricane Hazel on Process Water Quality at Riegel Carolina."

It was pointed out that adverse river conditions brought about by hurricane "Hazel" which struck the Carolina coast Oct. 15, 1954, were due to the very heavy drainage from the surrounding land into the Cape Fear River. This drainage resulted in great increase in turbidity and mineral content and a general deterioration of the properties of the water necessary to a high-quality bleached pulp at Acme, N. C.

The full story of their handling of this problem is given in the paper prepared by Mr. Phillips, Charles S. Ruark, George J. Simpson.

"The Design, Construction, and First Year's Operation of a One Million Gallon Per Day Bio-Oxidation Pilot Plant at Sonoco Products Co." was described by B. M. Reaves, engineer for the company.

As background information, Mr. Reaves described the products and production facilities of his company.

Considerable laboratory and pilot plant work preceded the decision to build the full-mill-scale bio-oxidation plant. Sonoco personnel also visited several mills with treatment plants to gain as much preconstruction experience as possible.

The full text of the paper by Mr. Reaves, J. E. Copenhaver, and C. Nevin Betts follows.

Joseph Velardi of Rayonier, Inc., gave a very interesting and somewhat humorous discussion of their method of acidizing water wells for flow improvement, worked out to step up the declining flow of their wells at Fernandina Beach. Since it was believed that carbonate deposits in the crevices of the water producing strata were the cause of the decline in water output, their problem was to confine the acid treatment to that area. Since this lay about 400 ft. from the bottom and 600 to 700 ft. from the surface, a plug had to be devised that would seal off the wells at that location, thereby allowing an inhibited hydrochloric acid to open up the crevices by dissolving the carbonate deposits.

Laboratory tests showed that black-eyed peas would fill their need, so a kraft paper liner was shaped small enough to fit into the well, filled with black-eyed peas, and placed in a burlap bag, forming a "bean bag" plug 6 ft. long, 14 in. in diameter, and holding 150 lb. of peas.

The well pump, column, and motor were removed from each well treated, the bag was lowered into place, a 3-in. pipe was lowered to within 25 ft. of the bag (by which time the bag had expanded), a spring scale was attached to the cable to register the weight of the bag and cable in the well. A pull of 150 to

*K. O. Elderkin, Bowaters Southern Paper Corp.; J. R. Lientz, Union Bag & Paper Corp.; and R. G. Coker, Sonoco Products Co.*

250 lb. in excess of the bag plus cable weight indicated that the hole was sealed.

A full description of this acidizing operation is given in the text of Mr. Velardi's paper.

The Southeastern Section was indeed fortunate and honored to have as its principal speaker of the evening, K. O. Elderkin of Bowater Southern Paper Corp. and president of National TAPPI.

Mr. Elderkin's paper has been previously submitted to TAPPI (See report of Delaware Valley Section), the following notes taken by Mr. Borlew are appropriate for inclusion in this report:

In the beginning of his paper Mr. Elderkin disclosed the very interesting phase of financing such a colossal enterprize as Bowater newsprint and kraft pulp mill at Calhoun, Tenn., which costs $60 million including timberlands. The publishing industry signed a contract to purchase the entire newsprint output for the coming 15 years and the Bowater Paper Corp. of England also undertook to import annually 50,000 tons of unbleached kraft pulp for the same period. The Certificate of Necessity allowed for a write-off to 45% of the costs of the mill in the first 5 years. Such extremely favorable conditions created a solid business foundation for a group of insurance companies to buy $37.5 million worth of bonds, while banks undertook to loan $7.5 million on notes. The balance of $15 million was financed by the parent corporation, whereby the British Treasury was persuaded to allow the transfer of precious American currency in view of the fact that the unbleached kraft is a raw material for Bowater's British mills.

After explaining the reasons for the particular choice of the mill site, which was the result of extended aerial surveys, the speaker went into some of the fundamental engineering problems which confronted his management at the start. One of them was the width of the two paper machines. An analysis of the roll size demand in the south called for a maximum trim of 228 in. For better edges and wet end running conditions an additional allowance resulting in a wire width of 254 in. was selected. The wire length as well as a suction transfer feature had to be adapted to the expected higher speeds. At the time of designing no machine in the south ran faster than 1500 f.p.m. for any extended time which was adapted as a guide for planning the pulp production. As the fastest newsprint machine in the world had never exceeded 1850 f.p.m. it was decided to plan for 2000 f.p.m. This was, as Mr. Elderkin characterized it, an error in judgment. For on April 27, 1955, 32-lb. newsprint was manufactured at Calhoun at 2118 f.p.m. on no. 1 machine without a break. This speed was attained in $3^1/_2$ hr. starting at 1720 f.p.m. and held at 2118 f.p.m. for $5^1/_2$ hr.

Another instance where management underestimated productive capacity was the largest built grinders for 5 ft. 3 in., wood sticks as cut in the mill area. As past experience indicated that a production of 43 tons per stone with a consumption of 3750 hp. could be expected, 4500-hp. motors were provided. However, experience taught that considerably more than 50 tons per stone could be produced and that the motors were too small. Thus a new grinder will be secured with a 6000-hp. motor. In the past in making newsprint the quality of groundwood was very important as so to be able to pull the sheet from the wire at high speeds onto the first press felt. Suction transfer has eliminated this requirement, and the quality of the groundwood is now solely determined by printability requirements.

Mr. Elderkin also mentioned other data of general interest, some hitherto unknown. To provide for a better planned wood inventory an underwater wood storage to hold 38,000 cords was built which also prevents deterioration of the wood and secures reasonably constant moisture content. In staffing the mill with 750 people, 200 of them were hired from within the industry, the rest from other walks of life who had to be trained for their jobs. The mill is currently producing 160,000 tons of paper and over 60,000 tons of export pulp (it was designed for 125,000 and 50,000 tons respectively).

The speaker observed that an important change is occurring now in our industry. Years ago, in any paper mill the operating workmen were the largest group at the mill at any time. With what is now called "automation" there are more maintenance and repair men than operators during the day shift. There are also more daytime supervisors, head office staff, and office people than there are operators. During the night shift there is only one man in the mill for every $400,000 of plant equipment.

Future management problems connected with the rising demand for paper estimated to double within the next 20 years would be to provide for an additional capacity of 1 to $1^1/_4$ million per year, not counting replacement of worn out plants. Since plants take at least 2 years to build this means that 3 million tons of capacity will be in construction at all times during the next quarter of the century. We must produce the trees, find the money, and find and train men and management, concluded Mr. Elderkin.

C. L. Smith,
*Recording Secretary*

## Effect of Hurricane Hazel on Process Water Quality at Riegel Carolina

*Noel R. Phillips, Charles S. Ruark, and George J. Simpson*

The Riegel Carolina Corp. is located on the Cape Fear River 30.5 miles upstream from Wilmington, N. C., and 56 miles from its mouth.

### DESCRIPTION OF WATER TREATMENT EQUIPMENT

Water from the river is brought to the pump house through a canal 200 ft. long and 8 ft. wide at the bottom. It is screened by means of a bar rack Model 46 Link Belt traveling screen, and by strainers around the pump suction to remove all debris such as sticks, leaves, fish, and other water-borne trash. Three Layne-Atlantic vertical turbine-type raw water pumps, each capable of pumping 5750 g.p.m. of water to a height of 78 ft., are used to pump the raw water to the filter plant. The quantity of raw water is maintained by the use of a flow rate controller at the filter plant. The distance between the pump house and the filter plant is 1200 ft. A nozzle for the addition of hypochlorite solution is located immediately after the rate controller. Duplicate Milton Roy metering pumps capable of delivering 217 g.p.h. of sodium

Noel R. Phillips, Technical Director, Charles S. Ruark, Technical Control Supervisor, and George J. Simpson, Chemical Engineer, Riegel Carolina Corp., Acme, N. C.

hypochlorite against a pressure head of 40 p.s.i. are used for this purpose, if needed. The water is then passed through a 24-in. American Well Works Homomix or rapid mixer. Nozzles are located for the addition of alum and milk of lime to the water in the rapid mixer. This unit consists essentially of two high-speed rotating agitators mounted in the pipe line just prior to a 90° elbow. The nozzles for chemical addition are placed over the agitators to insure thorough mixing. Adequate mixing of the flocculating chemicals is essential prior to passage of treated water to the flocculators and settling basins.

From the Homomix, the water passes to two flocculators through a flume containing a number of plug valves. The flocculators consist of two rectangular compartments in series, each 13 ft. wide, 45 ft. long, and 15 ft. deep. The water is gently agitated in two compartments by paddle agitators turning approximately 2 r.p.m., for 36 min. It leaves the flocculators through a "stilling wall," which is a wall of concrete blocks so constructed that from the center line down, the blocks are separated horizontally by 4 in. enabling the water to flow gently into the settling basins.

The water then enters any one of the three settling basins which are 140 ft. long, 50 ft. wide, and 16 ft. deep. There is approximately $3^1/_2$ hr. retention time in each basin. The settled material is periodically flushed to the sewer through a drain in the bottom, depending upon the silt depth in each basin. It is possible to flush the basins independently of each other, and to run the filter plant with one basin out of service.

Settled water is decanted from the surface and flows through a series of distributing flumes to any one of the six filters. The filters are 32 ft. long, 20 ft. wide, and carry a $3^3/_4$ ft. depth of water on top of the sand. The water enters the filter beds by overflowing five aluminum troughs which extend over the sand at right angles to the influent flume. Each filter has a designed capacity of 2 million g.p.d., and these filters were designed and installed by the Roberts Filter Manufacturing Co.

From the filters, the water passes into an after-mixing chamber 13 ft. by 7 ft. by $9^1/_2$ ft. A flash mixer extends vertically downward into the chamber. Alkali, complex phosphate compounds, and hypochlorite solution can be added to the after-mixing chamber if we desire to treat the water for any purpose after filtration. We are also equipped to add phosphate compounds into the filtered water header going to the mill.

The water then flows from the after-mix into a 1,700,000-gal. open reservoir which is directly connected to a 180,000-gal. clear well. It is possible to by-pass the reservoir and valve the water from the after-mix directly into the clear well. This is done when the open reservoir needs cleaning; this arrangement makes it possible for us to operate the mill independently of the reservoir.

***Joseph Velardi, Rayonier, Inc.; C. N. Rogers, Sonoco Products Co.; W. M. Ackerman, West Virginia Pulp & Paper Co.; and R. H. Homans, Brunswick Pulp & Paper Co.***

Three Worthington mill service pumps supply the finished water to the mill for process purposes. Each of these pumps is capable of delivering 5000 g.p.m. of water against a 110-ft. head. We have a vacuum priming system for the service pumps to insure that these pumps will not lose their prime during operation.

The finished water consumption for the past year averaged 16.8 million g.p.d. This is also the approximate capacity of the filter plant, in spite of the fact that its designed capacity is about 12.5 million gal. of water per day. In addition to the 16.8 million gal. of finished water, the filter plant furnished approximately 2 million g.p.d. of raw water to various places in the mill where treated water is unnecessary. Our raw water system is independent of the filtered water supply.

## PROPERTIES OF THE RAW AND FINISHED WATER

During the year 1954 the pH of the Cape Fear River water ranged from 6.0 to 7.2, and averaged 6.7. The turbidity varied from 25 to 350 p.p.m., and averaged 70 p.p.m. The temperature ranged from a minimum of 40°F. in December, to a maximum of 87°F. in August, with an average of 65°F. for the year. The color was never below 100 for the entire year. The alkalinity averaged 21 p.p.m. as calcium carbonate; the hardness, 30 p.p.m. as calcium carbonate; and salinity, 19 p.p.m. as chloride. The river flow averaged approximately 4 billion g.p.d., with a maximum of over 14 billion gal. and a minimum of 227 million g.p.d. These data averaged by months will be found tabulated in Table I.

The 16.8 million g.p.d. of finished water should have a zero turbidity, zero color, and less than 0.05 p.p.m. iron and man-

**Table I. The Basic Properties of Raw and Process Waters at the Riegel Carolina Corp. from January 1954 through March 1955**

| Month | Temperatures, °F. | | Turbidity, p.p.m. | | Color, p.p.m. | | pH | |
|---|---|---|---|---|---|---|---|---|
| | Raw | Process | Raw | Process | Raw | Process | Raw | Process |
| Jan. 1954 | 45 | 46 | 81 | 0 | 100 | 0+ | 6.5 | 7.0 |
| Feb. 1954 | 48 | 48 | 58 | 0 | 100 | 0+ | 6.6 | 7.0 |
| March 1954 | 52 | 53 | 101 | 0 | 100 | 2 | 6.6 | 7.0 |
| April 1954 | 64 | 64 | 71 | 0 | 100 | 5 | 6.5 | 7.0 |
| May 1954 | 70 | 70 | 67 | 2 | 100 | 3 | 6.8 | 6.9 |
| June 1954 | 80 | 81 | 62 | 0 | 100 | 5 | 6.8 | 6.9 |
| July 1954 | 84 | 84 | 65 | 0 | 100 | 3 | 6.9 | 6.9 |
| Aug. 1954 | 85 | 85 | 70 | 0 | 100 | 2 | 6.9 | 7.0 |
| Sept. 1954 | 81 | 81 | 65 | 0 | 100 | 1 | 7.1 | 7.0 |
| Oct. 1954 | 69 | 69 | 87 | 0 | 100 | 1 | 6.6 | 6.9 |
| Nov. 1954 | 57 | 57 | 55 | 0 | 100 | 1 | 6.5 | 7.1 |
| Dec. 1954 | 45 | 45 | 62 | 0 | 100 | 3 | 6.9 | 7.0 |
| Jan. 1955 | 47 | 47 | 39 | 0 | 100 | 1 | 6.9 | 7.4 |
| Feb. 1955 | 46 | 46 | 69 | 0 | 100 | 0+ | 6.7 | 7.5 |
| March 1955 | 60 | 58 | 44 | 0 | 100 | 0+ | 6.8 | 7.4 |
| Av. | 62 | 62 | 66 | 0 | 100 | 2 | 6.7 | 7.1 |

*Note:* It should be kept in mind that the above are monthly averages; maxima and minima may be considerably above or below the averages.

ganese for our process use. As can be seen from the variation in our water supply, careful control is absolutely essential to make sure that we will have the quality of water that we need.

### HURRICANE "HAZEL"

On Oct. 15, 1954, Hurricane Hazel struck the North Carolina Coast. On October 14, the river flow was at its minimum year's rate of 227 million g.p.d.; by October 19, the flow was over 14 billion gal. The actual flow is not known because it was above the Geological Survey rating curve for our section of the Cape Fear River. The turbidity had increased from 65 p.p.m. to 350 p.p.m., and the pH decreased from 7.1 to 6.0. The iron had increased from a normal range 0.3–0.4 to 0.74 p.p.m., and the manganese content from 0.1 p.p.m. to 0.5 p.p.m. in the raw river water.

These changes in the raw water made it extremely difficult to suitably flocculate the raw water. The color in the finished water increased from zero to 10; the turbidity, however, remained at zero. The iron increased to 0.10 p.p.m. and the manganese to 0.40 p.p.m. in our finished water. Due to these changes in our process water, some difficulty was experienced in maintaining our high standards for brightness and dirt in our bleached pulp. Table II contains data that show the effect of "Hazel" on our raw and process waters.

In order to maintain the standards of less than 0.05 p.p.m. iron and manganese in the finished process water that is required for making high-quality bleached pulp, it was decided to introduce the hypochlorite solution at the pump house instead of at the Homomix. This would allow a longer period of time to permit oxidation of the manganese and iron in the raw water. By introducing the hypochlorite at the river pump house, we would be able to practice breakpoint chlorination of the raw river water. Theoretically, at least, true breakpoint chlorination should result in a reduction of iron and manganese to the limits of 0.05 or less for iron and manganese that we feel is essential for our water.

Another factor of water treatment that helps in removal of iron and manganese is flocculation at higher pH values. We raised our flocculation range from 5.3 to 5.5 to the range of 5.8 to 6.1 in an effort to remove as much iron and manganese as possible. A new liquid alum system which had recently been completed was put in operation through an automatic controller to insure this pH range being maintained. This made it possible to have a standby dry feeder for use, if necessary, with some coagulant other than alum. A liquid lime system is now being installed for the addition of lime to both the Homomix and to the after-mixing chamber. This will permit us to use completely automatic, liquid systems for pH control of the mixed water and the finished filtered water. To keep the activity of our finished water low, we maintain the finished pH in the range of 7.4 to 7.6 pH.

Prior to Hurricane Hazel, the silt in the settling basin had been removed at approximately monthly intervals. This allowed a considerable depth of silt to build up before the basins were emptied and cleaned. At the present time, silt depth is measured weekly, and the basins are cleaned when the depth reaches 20% of the basin height or a depth of 3.2 ft. Keeping the basins free of silt permits sufficient time to allow the floc to settle out, and also prevents the possibility of silt carryover into the filter beds.

As a further safety measure, we wash our sand gravity filters whenever they show a loss in head of 5 ft. This is a safety measure to insure that our filter beds will not become sealed and require drastic action such as chemical cleaning of the filter beds. In order to reduce the possibility of corrosion in the pipe lines in the mill, 3 p.p.m. of a complex phosphate compound is added either in the after-mixing chamber or directly into the main header for process water as it is pumped to the mill.

**Table II. Effect of Hurricane Hazel on Raw and Process Waters at Riegel Carolina Corp., Acme, N. C.**

| Time interval | Iron content range, p.p.m. Raw water | Iron content range, p.p.m. Process water | Manganese content range, p.p.m. Raw water | Manganese content range, p.p.m. Process water |
|---|---|---|---|---|
| Oct. 19–Nov. 23, 1954 | 0.4–1.9 | 0.1–0.5 | 0.1– 0.5 | 0.1–0.4 |
| Dec. '54–March, '55 | 0.1–0.5 | 0.0–0.1 | 0.05–0.15 | 0.03–0.1 |

### CONCLUSIONS

The adverse river conditions brought on by the hurricane were due to the very heavy drainage of the surrounding land into the river. This drainage through swamp and farm land caused the great increases in turbidity and mineral content of the river. It has been found that by using the operating procedures as outlined, the standard of zero color and turbidity can be maintained. The iron can be held to 0.05 p.p.m. or less. However, the removal of manganese has proved to be more difficult. When the manganese content is at the normal level of 0.1 p.p.m., it has been found that a reduction of 30 to 50% is obtained most of the time. There have been occasional periods when we have had no reduction in manganese. There have been rare occasions when the river water has contained from 0.15 to 0.2 p.p.m. manganese. The operating methods described herein have enabled us to effect manganese reductions in the range of 0.07 to 0.1 p.p.m. when the raw water has been in the range of 0.15 to 0.2 p.p.m. manganese. We are continuously experimenting with our water treatment methods, and we feel that we will be able to maintain our high water quality in regard to the permissible standards of 0.05 p.p.m. or less of iron and manganese in our finished water. Our experience to date has shown us that we can secure zero color and zero turbidity with our present operating practices regardless of the condition of the raw river water. We have learned that filter plant operation requires careful, scientific, accurate control if we are to produce a high quality water for our purposes.

## The Design, Construction, and First Year's Operation of a One Million Gallon Per Day Bio-Oxidation Pilot Plant at Sonoco Products Co.

*B. M. Reaves, J. E. Copenhaver, and C. Nevin Betts*

In March of this year Sonoco Products Co. completed its first year of operating a 1 million g.p.d. bio-oxidation pilot plant for treating paper mill waste waters. This is a case history of the plant, telling how and why a plant of this particular type and size was selected, its design, construction, and the good and bad results of the first year of operation.

For those who are not familiar with our company, it will probably be best to give a brief background of our operations. Sonoco's primary products are paper cones and tubes used as yarn and thread carriers in the textile industry. We also manufacture a variety of cores for use in the paper industry. A relatively new, but fast growing product is the spirally-wound paper tubes used in the construction trade for circular concrete column forms, voids in concrete slabs, and air duct in perimeter heating installations. To supply the paper for these products, Sonoco has, in Hartsville, eight cylinder machines which produce numerous varieties of chipboard, mostly from waste news and corrugated boxes. Production from these eight machines ranges from 300 to 350 tons per day. The company also has one fourdrinier machine producing 9-pt. corrugating board from neutral sulphite, semi-chemical pulp. Production from this machine is approximately 135 tons per day and is all sold to an outside customer. The receiving stream at our plant is known as Black Creek.

B. M. Reaves, Engineer, J. E. Copenhaver, Chief Chemist, and C. Nevin Betts, Paper Mill Chemist, Sonoco Products Co., Hartsville, S. C.

It has a flow varying from a high of 485 to a low of 102 cu. ft. per sec, while its average flow is 250 cu. ft. per sec.

In a manner that is familiar to the paper industry as a whole, Sonoco has long been "closing up" its paper machine water systems by developing the re-use of white water and installing equipment to recover the suspended solids. This program has successfully lowered our per cent loss of suspended solids from the paper mill from 3.09% in 1942 to 0.92% in 1953, and the gallons fresh water per ton of paper from 40,800 gal. in 1942 to 15,700 gal. in 1953. Despite these improvements, and as plant and production increased, it became evident that additional measures must be taken to lower the pollution load in the waste waters being returned to the stream. It was also evident that we must concentrate on reducing the load caused by dissolved solids in the paper mill waste waters.

Early in 1951 laboratory scale experiments were tried to see if the bio-oxidation process would work on Sonoco's waste waters. The results were favorable. Based on this, it was decided to investigate further and a small pilot plant with a flow of 2 g.p.m. was built. This pilot plant was operated for 4½ months. Again, the results indicated that dissolved solids in our waste waters could be successfully treated with the bio-oxidation process.

In case some of you are not familiar with the bio-oxidation or activated sludge process, let me give a brief description of it before going any further. It consists of removing suspended solids from raw, untreated water in a primary settling tank, and mixing the clarified untreated water with a sludge, highly concentrated with aerobic bacteria. Then the mixture is held in a detention tank where it is agitated by air while the bacteria digest the soluble solids. The mixture is then passed to a secondary settling tank where the sludge is settled, collected, and recirculated for re-use. The clarified, treated water is drawn off at the surface and, usually, discharged into a flowing stream.

While these pilot plant operations were being conducted, Sonoco personnel were visiting and observing pilot plant operations at Southland Paper Co., Lufkin, Texas, West Virginia Pulp & Paper Co., Covington, Va., and the pilot plant operated by the National Council for Stream Improvement at Macon Kraft Corp., Macon, Ga.

After concluding the small scale pilot plant operations, it was decided to retain Clair Sawyer to study our problem and give his recommendations. Mr. Sawyer is a consultant with the engineering firm of Metcalf and Eaddy, Boston, Mass., and also professor of sanitary engineering at Massachusetts Institute of Technology. After studying our problem, Mr. Sawyer advised that, in addition to the bio-oxidation process, we consider the trickling filter method of waste treatment before reaching a final decision as to the type and size plant to build. A trickling filter operation was considered, but it was felt that enough information was already available on this type process so that no pilot plant operations were necessary. To help in determining the size plant to build, cost estimates were made for both bio-oxidation and trickling filter systems for flows of 100, 200, and 700 g.p.m., the last value being equivalent to 1 million g.p.d. In addition to the estimated cost, the salvage value for each size plant was determined in event of future enlargement to handle more mill waste water.

In September, 1952, it was decided to proceed with the existing 1 million g.p.d. bio-oxidation plant. Reasons for selecting this size plant were:

1. It was desired to have a plant with enough capacity that its effect would be felt in the over-all stream pollution picture.
2. We felt that with a plant this size, we could best determine how to integrate its necessarily continuous operation with the normal 5 day per week operation of the paper mill.
3. With a plant this size, future expansion could be done on a unit basis. We felt this was desirable since it insures partial operation during most mechanical failures, and it also allows certain units to be shut down during winter months when the stream can receive a higher B.O.D. load.

Once the type and size plant was decided, Sonoco requested that the National Council for Stream Improvement send one of its sanitary engineers to advise on the design of the plant. Accordingly, in October, 1952, A. J. Paladino spent several days at Sonoco, during which the preliminary engineering for the plant was completed. From this point the design and construction of the plant was supervised by the Sonoco engineering department.

The only available space for a plant site was a section of swampy ground adjacent to the receiving stream. We realized that this area contained relatively poor foundation soil, but felt we could repair any trouble caused by settling cheaper than we could install piles on which to build the plant. Approximately 1 acre of this land was cleared of undergrowth and filled with sand-clay.

It was decided that the aeration and clarifier tanks would be rectangular and would be one unit. Construction was to be reinforced concrete. This developed into a tank 130 ft. long, 36 ft. wide, and 13 ft. deep. Water depth is 12 ft. The tank walls are 10 in. thick and the floor is 6 in. deep. The tank contains two full-width expansion joints through floors and walls. Except for a 10-ft. length at one end, the tank is divided into two 18-ft. channels by a mid-wall. This allows the influent water to travel the length of the tank, make a U-turn and discharge out the same end of the tank that it entered. The aeration tank is sized to have a retention time of 6 hours based on a flow of 700 g.p.m. raw influent plus 25% recirculated sludge. This is a volume of 317,000 gal. and requires 195 ft. of the 18-ft. wide channel. The clarifier and aeration tank are separated by an 8-ft. high wall across the 18-ft. channel.

The aeration tank walls have at the top a 2-ft. overhang which comes out from the wall at a 45° angle. This is a common feature in sewage treating tanks and the purpose is to give a spiral motion to the water as it is agitated by the air, thereby keeping the suspended solids in suspension. To simplify construction, this overhang was also built into the clarifier walls. The tank walls are tied across the top with 2½-in. diam. extra heavy pipe, anchored in the concrete, and spaced 12 ft. 6 in. on centers. Thus, the walls are tied at top and bottom eliminating any cantilever effect from the water load. The influent and effluent water troughs are formed as part of one end wall. As an economy measure, it was decided to place Sonoco's Sonovoid tubes in the overhang section of the walls. Twenty 4-in. diameter Sonovoids were used in the mid-wall and 12-in. diam. Sonovoids were used in the side and end walls. These tubes replaced approximately 25 cu. yd. of concrete which represents a saving of over $500.

The clarifier tank has the same dimensions as the aeration except the length is 65 ft. This gives a volume of 103,000 gal. and a retention time of 2 hr. The floor of the clarifier has a 1% slope from the influent end. Settled sludge is collected by means of an American Well Works straight-line collector which drags the sludge down the sloped floor to three sumps at the effluent end of the tank. The sludge is pumped from the sumps to a measuring weir, from which it flows to the system for recirculation.

The control house is a 20 by 20-ft. building constructed of concrete blocks, with reinforced concrete floor and roof. The house is divided into two sections, one housing the laboratory and instrument panel, and the other housing the air blower, sludge pump, power transformer, switches, and other equipment. The laboratory is equipped with a water still, a constant temperature bath for B.O.D. determinations, and necessary apparatus for performing D.O., B.O.D., sedimentation, suspended solids, and dissolved ammonia nitrogen tests. We are fortunate in having a flowing well nearby from which

*Fig. 1. Bio-oxidation pilot plant at Sonoco Products Co.*

a continuous supply of fresh water at 20°C. is available for our constant temperature bath.

The air blower is a U. S. Hoffman centrifugal blower rated at 2000 c.f.m. capacity and driven by a 100-hp. motor. Air is distributed through an 8-in. main located on top of the mid-wall in the tank. From the air main there are fifteen 3-in. down pipes which connect to 3-in. headers located 12 in. above the tank floor. Each header contains from 12 to 24 3/4-in. distribution pipe, each having twenty-four 1/8-in. holes for air outlets. We considered using porous plates or diffuser tubes for air distribution, and this would have given higher absorption efficiency with less horsepower, but the clogging factor of our water, which was unknown, caused us to decide on perforated pipe. The 3-in. down pipes were installed so that a pipe union could be loosened, and the down pipe and header rotated up and out of the water by means of a stainless steel cable and portable winch located on the opposite wall of the tank. This allows maintenance work to be done on the pipes without draining the tank.

Weirs for measuring influent water from the paper mills, and recirculated sludge are located on top of the control house. The weir for measuring effluent water from the treating plant is located on the ground beside the clarifier and is fed by gravity. All weir boxes are concrete.

Included in the plant make-up is a 50,000-gal. wooden tank which is used for storage of black liquor from the semichemical pulping operations. The purpose of this is to have a supply of high B.O.D. feed available to the plant for week ends when the paper mills are not operating.

The operating cycle for the plant naturally begins in the paper mill. White water from the chip board operations is collected in a surge tank, and pumped to a Waco filter, which is a pre-coat type of filter. Screened water from the Waco is pumped with a 1000-g.p.m. Ingersoll-Rand pump through 900 ft. of 8-in. pipe to a weir on top of the control house. White water from the semichemical operation is collected in a 50-ft. diam. Dorr clarifier, and from here the clarified water is pumped through 700 ft. of 6-in. pipe to another weir on top of the control house.

The flow of semichemical water is intermittent with the paper machine system getting first chance to use the water for stock preparation. A manual valve was first used to maintain a maximum peak flow of semichemical water, but has since been replaced by a diaphragm-operated butterfly valve. This valve is controlled by a recording controller sensitive to the hydraulic head over the semichemical weir. From here, the semichemical water flows by gravity into the chipboard weir. The flow of chipboard water is also controlled by a butterfly valve which is sensitive to the hydraulic head on it weir. Since this flow is both the semichemical and chipboard waters, there is a control on the total flow to the treating plant, and at the same time, variations in flow of semichemical water are automatically compensated for with chipboard water.

The influent waters are mixed with the recirculated sludge in a small mixing box, and the mixture flows by gravity into the aeration tank and on into the clarifier. The collected sludge in the clarifier is pumped from the three sumps by a centrifugal pump—a 400-g.p.m. Ingersoll-Rand—up to the sludge weir on top of the control house. This flow is measured and recorded.

Originally, sludge flow was controlled with three manual valves on the suction lines from the sumps, but it proved very difficult to keep equal suction pressure on each line and this caused clogging in the pipes. We are now installing a sludge control box into which the sludge will flow due to a hydraulic head between the clarifier and the control box. Flow from the control box to the sludge pump will be automatically controlled with a butterfly valve, sensitive to the sludge head inside the box.

Agricultural grade anhydrous ammonia is used as a nutrient for the bacteria and is admitted into the suction side of the sludge pump. This ammonia was originally bought in 150-lb. bottles, using banks of three bottles at a time. We are now using 2000-lb. trailer tanks at a cost of 8 1/2¢ per lb. Ammonia flow is controlled by a manual valve and measured with an indicating flow meter.

Instrumentation for the plant consists of Minneapolis-Honeywell recording controllers on semichemical and chipboard water flow, and Foxboro flow recorders on effluent water, sludge, air, and black liquor. All recorders for liquid flows have bubble pipes for sensing elements. The air flow is measured by the differential pressure across a sharp-edged orifice.

Cost for the construction of the plant and installation of equipment is as follows:

| | | |
|---|---|---|
| 1. | Clearing plant site, backfill, and grading | $ 1,488.94 |
| 2. | Aeration and clarifier tank, clarifier equipment and control house | 32,542.31 |
| 3. | Pumps, pipes and valves | 21,014.11 |
| 4. | Air blower and filter | 4,301.77 |
| 5. | Instrumentation | 3,867.16 |
| 6. | Electrical wiring and controls | 7,434.29 |
| 7. | Black liquor storage tank | 1,023.75 |
| | Total cost | $71,582.33 |

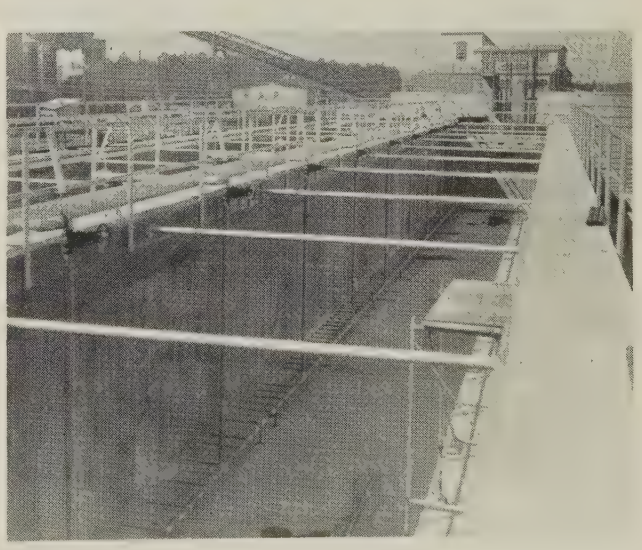

*Fig. 2. Tank showing pipes tying walls across top and aeration bubble pipes*

Seeding of the plant was started in late March, 1954, using primary and secondary settled sludge from the nearby municipal sewage plant, a trickling filter operation. Herbert Berger of the National Council was at Sonoco and worked with C. N. Betts, paper mill chemist, during the seeding and start-up operations.

Sonoco's chipboard waters were first fed to the plant on April 5, 1955. It was immediately evident from the sludge being carried over the effluent weir in the clarifier, that additional weir length was needed. Eight half sections of 8-in. diam. pipe, each 20 ft. long, were installed as overflow weirs for clarified water. This gave 320 lineal ft. of overflow weir, and for our maximum flow was well above the minimum recommended standard of 5000 g.p.d. per ft. of weir length. Also, at this time, an adjustable overflow gate was installed at the partition wall between the aeration section and the clarifier. This was done to keep the high water velocity caused by the circulating air from being carried over into the clarifier and upsetting the settling action. During this period of structural changes, minimum flow and feed requirements for supporting bacterial life were maintained.

In early May the plant was brought to 700 g.p.m. flow on chipboard water having a B.O.D. concentration of 250 p.p.m. At this time a small flow of semichemical water was started. Its B.O.D. concentration was 2500 p.p.m. As the flow of semichemical was increased, the sludge became overloaded and would not settle properly. This is termed as "bulking" sludge. At this time the stream was reaching its critical pollution stage and it was decided to keep a high B.O.D. load into the plant while attempting to correct the trouble, so that the stream would be relieved as much as possible. This period of bulking sludge lasted from mid-May until mid-July and during this time the additions of clay, agricultural limestone, and a bactericide, along with variations of air and influent water to the plant were tried as corrective measures. None worked and the final solution was simply reducing the B.O.D. load enough to allow the mixed liquor in the aeration

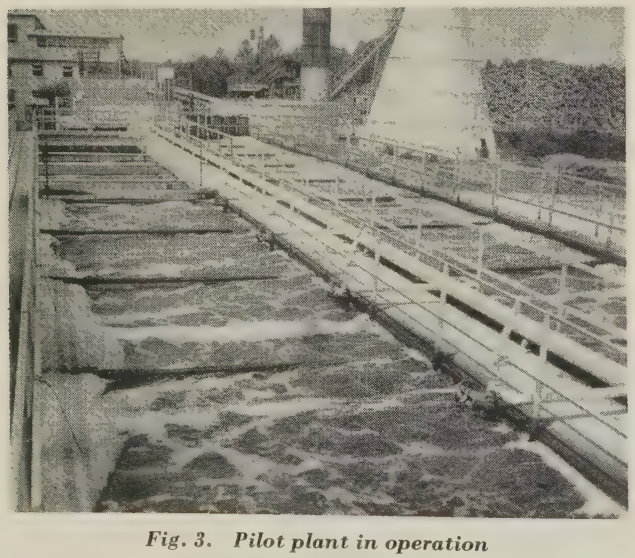

***Fig. 3. Pilot plant in operation***

tank to become well saturated with dissolved oxygen. During this period average data figures were as follows:

| | |
|---|---|
| Waste water flow, g.p.m. | 525 |
| B.O.D. removed per day, lb. | 1675 |
| B.O.D. conc.—influent, p.p.m. | 354 |
| B.O.D. conc.—effluent, p.p.m. | 78 |
| B.O.D. removal—efficiency, % | 78 |

The first period of "bulking" sludge was by no means the last. In September a long, stringy fungous growth developed and kept the sludge from settling properly. This growth was visible to the eye, and reached lengths of 4 to 5 ft. The remedy in this case was feeding an excessive amount of ammonia. In November, an excess of paper fiber got into the bio-oxidation system due to holes in the screen on our Waco filter. This was corrected by dropping the B.O.D. load to the plant and allowing the bacteria to digest the fiber. The most difficult case occurred during December and January when a microscopic filamentous growth developed.

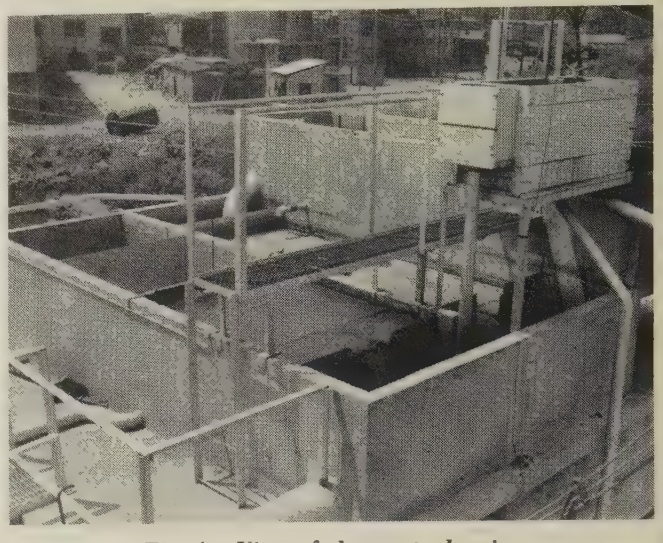

***Fig. 4. View of the control weirs***

This caused such bad sludge conditions that we were considering dumping the plant and reseeding when a cure was found. This cure was subjecting the sludge to alternate periods of aerobic and anaerobic conditions and was done by holding the sludge longer than normal in the clarifier.

Although we had intermittent periods of poor clarification, we did have a period of good operation which lasted from July through mid-October. Average flow figures during this time were:

| | |
|---|---|
| Waste water flow, g.p.m. | 500 |
| B.O.D. removed per day, lb. | 1758 |
| B.O.D. conc.—influent, p.p.m. | 340 |
| B.O.D. conc.—effluent, p.p.m. | 43 |
| Efficiency, % | 87 |

During this period, the flow was approximately 7% semichemical and the balance chipboard. Air consumption was approximately 2000 c.f.m. Since the total paper mill waste load per day to the stream varies during the summer from about 8000 to about 16,000 lb. B.O.D., and since we also operate a 375-g.p.m. spray farm for semichemical water during summer months, we cannot accurately say what percentage of the total B.O.D. load from the paper mills was handled by the bio-oxidation plant.

Plant operations steadily became worse from November until January, primarily due to the microscopic filamentous growth that developed. By January flow to the plant had dropped to 275 g.p.m. and efficiency was down to 56%. In late January when it looked as if we had the sludge problem solved another headache developed. The expansion joints opened up due to excessive settling of the tank, and the leakage became so great that a sufficient rate of sludge build-up could not be maintained. Thus, it was necessary to drain the tank and repair the leaks.

The repair period was much longer than we anticipated, lasting from early February through mid-March. The first effort to seal the joints failed, but the second effort proved successful. The material used was an asphaltic expansion joint cement manufactured by Minwax Co., Inc. At present, the joints are watertight.

When re-seeding of the plant was started, sludge from the city sewage plant was unavailable and it was decided to at-

tempt to develop sludge by aerating our chipboard water. This proved successful and the re-seeding required only 3 weeks before the sludge was able to take a flow of 700 g.p.m. chipboard water.

*N. R. Phillips, Riegel Carolina Corp.; B. M. Reaves, Sonoco Products Co.; W. C. Chapman, Union Bag & Paper Corp.; and M. B. Pineo, Brunswick Pulp & Paper Co.*

In January, Wesley Eckenfelder of Weston, Eckenfelder, and Hood, Inc., Patterson, N. J., had been retained to advise on any mechanical or operational changes he thought necessary to improve our operations, with particular emphasis on aeration equipment. However, before Mr. Eckenfelder could gather any background material, the leakage trouble developed and his work has necessarily been held up. Total operating cost, from April, 1954, through March, 1955, are $14,960.60 for an average of $1246.72 per month. Included in this cost is the additional overflow weirs, the adjustable gate between aeration and clarifier, and the expansion joint repairs.

After operating a bio-oxidation pilot plant for 1 year, we have the following comments and conclusions:

1. This type operation will successfully treat our paper mill waste waters.

2. Week-end shutdowns of our paper mill production will have no bad effects on the bio-oxidation operations. After

*C. L. Smith, National Container Corp.; G. E. Scofield, Rayonier, Inc.; G. C. Kimble, Union Bag & Paper Corp.; and N. R. Phillips, Riegel Carolina Corp.*

providing black liquor feed for only a few week ends, we concluded that this operation was not necessary.

3. The plant has not yet successfully handled the B.O.D. load that we anticipated. For last summer's operation we removed an average of 39.5 lb. B.O.D. per 1000 cu. ft. of aeration tank per day. This is higher than most municipal plants but well below the operation of the pilot plant at Macon Kraft Corp. which averaged 78 lb. We do not believe we have yet reached the top efficiency of this type operation on our waste waters. We are contemplating equipment changes which will enable more efficient operation and more complete evaluation by the end of this summer's operation.

4. We consider the operating costs high. We hope that if the plant operates relatively trouble-free this summer, this cost will be reduced. We definitely feel that the plant can be operated satisfactorily with the equivalent of one operator for one shift per day.

In the above presentation we have related the good and bad points of the bio-oxidation method as applied to disposal of our paper mill effluent. We hope the enumeration of some of the problems encountered and our attempt at their solution, will be of value to those of you who have or contemplate such an operation.

## Acidizing Water Wells For Flow Improvement

*Joseph Velardi*

In the pulping process, the two basic raw materials are wood and water. On a weight basis, water represents by far the largest quantity of raw material used. The importance of water in industry has become more apparent to all of us during the past few years. Recently, the Florida Municipal and Public Health Council meeting in Gainesville, Fla., was devoted entirely to the subject of "Water Management." The pulp industry in the Southeast is extremely fortunate in having available one of the most prolific sources of ground water in the world. This source extends over a wide area, is easily accessible by drilling, and contains almost unlimited quantities of high quality water.

It is not the object of this paper to discuss long-range water procurement projects, but to describe the technique used by the Fernandina Div. of Rayonier Inc. to replenish the dwindling flow of water from its well system. At Fernandina, we have nine wells, delivering 35 million g.p.d. This amount of water is necessary to maintain full production of our high quality bleached chemical cellulose. It has been our experience at Fernandina that the production capacity of water wells declines gradually over a period of time. Our problem has been to replenish this diminishing supply. To date, several methods have been tried—the latest being the Dowell acid treatment. At this point I think it would be proper to describe the physical characteristics of our wells. These wells are approximately 1000 ft. deep, cased with 18-in. pipe to 550 ft. The main water-producing strata is the so-called "Ocala formation," which in our area lies 600 to 700 ft. below ground level. The Ocala formation is primarily limerock. It has been theorized that the decline in water output of our wells is due to an accumulation of carbonate materials around the crevices delivering water to the well hole, much like the formation of stalactites in caverns. It was believed that it would be possible to dissolve these carbonate deposits with hydrochloric acid, thereby opening up the formation and permitting an easier passage for the water into the well hole. The Dowell Co. has developed an inhibited acid for just this purpose. In the first well which we attempted to treat, the acid was simply pumped into the well hole without removing the pump or column. The initial results obtained from this test proved very satisfactory. However, in a few months, the output of the well declined, and the gain previously obtained was lost. Since our wells are 1000 ft. deep and the Ocala formation lies at a depth of 600 to 700 ft., it was reasoned that if the action of the hydrochloric acid could be restricted to the Ocala formation, then

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the acid would be concentrated in the most productive region of the well. In other words, a plug was needed which would allow us to confine the action of the acid to the water-producing area of the well. Mechanical seals were available, but there was always the danger that it might not be possible to remove these seals from the well. We had to be sure that any seal placed in the well hole could be removed easily. So, the idea of mechanical plugs was discarded. The Dowell Co. had a partial answer to this problem. They have developed a material called "Jelliseal," which could be pumped into the well as a fluid where it would solidify in a very short period of time. After a longer period of time, bacterial action would decompose the plug and make it possible to pump it from the well. The question then arose as to what would be used to prevent the Jelliseal from falling to the bottom of the well before having a chance to harden. The problem then resolved itself into finding a suitable temporary support for the Jelliseal. During a conference to discuss this particular problem, someone facetiously suggested pouring beans into the well, allowing them to swell up, and thereby seal off the hole. On examination, the idea appeared to be worth consideration, and laboratory tests were made to determine which variety of bean would have the most suitable expansion properties. Many varieties of beans were tested—navy beans, pinto beans, kidney beans, and black-eyed peas. To the surprise of everyone, but in the best traditions of the South, black-eyes peas were found to have the greatest coefficient of expansion. In spite of a perplexed purchasing department, enough black-eyed peas were obtained to construct an experimental "bean bag." As a preliminary test, this bag was hung in a vertical section of 18-in. pipe, filled with water, in an effort to duplicate well conditions. It was found that the maximum expansion was obtained after 4 hr. of soaking. By this time, more than 100 lb. of pull could be exerted on the bag without dislodging it from the pipe—thus indicating that the bag had formed a satisfactory seal against the walls of the pipe. In 12 more hours, the peas had become mushy, loosening the tight fit, and allowing us to remove the bag with ease.

Here it might be well to discuss the construction of the so-called "bean bag." A kraft paper liner is shaped into a cylinder small enough in diameter to allow it to pass through the casing of the well. The paper liner is filled with black-eyed peas and placed in a large burlap bag. The loose folds of the burlap bag are pleated around the paper liner and the pleats held in place with rubber bands to prevent the burlap from being caught on the sides of the well. A $^3/_8$-in. steel cable runs through the entire length of the bean bag and is so clamped that the peas can expand laterally, but not vertically. Figure 1 is a photograph of a completed bean bag, ready for use. The finished bag is 6 ft. in length, 14 in. in diameter, and contains approximately 150 lb. of black-eyed peas. When in place, this bag can expand to 24 in. in diameter.

We are now ready to discuss the actual treatment procedure. In general, the following technique was used, but it should be understood that the difference in physical characteristics of the wells made it necessary to modify this technique from well to well. The first step in the procedure is to remove the pump, column, and motor. The bean bag, properly weighted, is then lowered into place at an approximate depth of 700 ft. on the $^3/_8$-in. steel cable. A 3-in. pipe is lowered to within 25 ft. of the bean bag. The placement of the pipe requires some 3 to 4 hr., which allows the bean bag sufficient time to expand. A spring scale is attached to the cable supporting the bean bag, and registers the weight of the bag and cable in the well. After 1 or 2 hr., the cable and bag are lifted by the scale in order to determine whether or not the bag has swollen sufficiently to drag on the walls of the well. When a pull of 150 to 250 lb. in excess of the weight of the bag and cable is obtained, it may be assumed that the bag has sealed the hole. By this time, the Jelliseal has been prepared and is quickly pumped into the well hole through the 3-in. pipe. The pipe then is flushed with sufficient water to insure complete removal of the Jelliseal from the pipe. The outfall of the 3-in. pipe is raised 100 ft. This exposes all of the Ocala formation between the bottom of the casing and the Jelliseal to the action of the acid.

Eight to ten thousand gallons of acid are then pumped into the hole through the 3-in. pipe over a period of about 1 hr. The acid is followed by 5 to 10 thousand gal. of water to force the acid back into the crevices of the formation. Exactly what occurs 600 ft. underground from this point on is somewhat problematical. However, the acid is allowed to react over night; and the following day, the pipe is withdrawn, along with the bean bag.

The pump is replaced and the well is pumped to the ground for several hours, to remove the spent acid. Periodic checks made on the chloride content of the effluent water give a reliable indication of the progress of this removal. Generally, after 4 to 6 hr. of pumping, the water has cleared up sufficiently so that it may be returned to the water system.

*Fig. 1*

These, in essence, are the major steps in the acid treatment procedure.

What are the benefits we have experienced from this treatment program? To date, nine treatments have been made. In no case has the original capacity of a well been recovered. However, initial gains of $^1/_2$ to $4^1/_2$ million g.p.d. per well, have been realized. In at least two cases, wells are now being used that would have been abandoned had it not been possible to rejuvenate them by acid treatment. Projecting the normal rate of decline of our total water putput, it was predicted that our water supply today would have been only 25 million g.p.d. and a new well would have been required. Instead, we now have a total water supply of 35 million g.p.d. In other words, by acid treating, we not only halted the decline in water output, but actually made a gain of 3 million g.p.d .over the production prior to the acid treatment program. While this program may not have made Rayonier the largest producer of water in the Southeast, it has at least made us the largest industrial consumer of black-eyed peas.

# Bacteriological Examination of Pulp*

***TAPPI Corrected Tentative Standard T 228 m-55***

(THIS STANDARD IS UNDER THE JURISDICTION OF THE MICROBIOLOGICAL COMMITTEE)

THE following procedure is recommended for the bacteriological examination of wet and dry pulp in sheet form. The procedure for examination of slush pulp is included in T 631 m. Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well-trained technician.

## APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform approximately 6 inches in diameter to readily accommodate Petri dishes. It should be sensitive to 0.1 gram.

3. *Corkborers.* Standard corkborers 15 to 25 mm. in diameter, used for taking samples from rolls or sheets. These are sterilized in screw-cap bottles.

4. *Bottles for Corkborers.* Screw-cap bottles large enough to hold one corkborer.

5. *Bottles for Dilution.* Several 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw cap or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

6. *Bottles for Wet Samples.* Several 4 to 8-ounce, wide-mouthed, glass-stoppered bottles are used for collecting wet lap-stock samples. The type of bottle selected should be able to withstand sterilization. Prior to sterilization, the stoppers and the necks of the bottles are covered with metal foil or heavy kraft paper to protect the lip of the bottle from contamination. A strip of paper may be inserted in the mouth of the bottle to prevent sticking of the stopper during sterilization.

7. *Colony Counter.* Any one of several types may be used. The Quebec, Buck, and Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

8. *Containers for Dry Samples.* When the sampling and testing is done in the same mill, a single envelope may be employed; otherwise, two single envelopes, one placed inside the other, are used. The larger one may be 9 by 12 inches and the smaller 6.5 by 9.5 inches. They should be made of a heavy kraft paper which will withstand sterilization in the hot-air oven without embrittlement. After sterilization, the flap on the outer envelope is secured by pressure-sensitive tape.

An alternative is to make a folder of suitable size from heavy kraft paper and sterilize it in the oven. After the pulp sample has been placed inside the sterile folder, the latter is sealed with the tape.

9. *Cotton.* Nonabsorbent cotton is used for plugs.

10. *Disintegrators.* Metal cup-type, with a high-speed impeller near the bottom. A kraft paper cover is placed over each disintegrator cup or jar prior to its sterilization by steam heat.

11. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp, a gasoline blow-torch or a Bunsen burner may be used to flame tongs, scissors, knives, and the mouths of sterile containers.

12. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

13. *Incubator.* Capable of maintaining a temperature of 36 ± 1°C. (96.8 ± 1.8°F.) to provide proper incubation conditions for the inoculated plates.

14. *Knives.* A knife with an inserted blade (Stanley) may be used to cut pulp. A paring knife with its blade cut down to within 1.5 inches of the base of the handle is also satisfactory.

15. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

16. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening about 3 mm., in diameter at the delivery end, are best for pipetting pulp suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipet. The pipets are sterilized in metal boxes or in heavy kraft paper.

17. *Scissors.* A satisfactory type has 4-inch cutting edges.

18. *Nutrient Substrate.* Dehydrated standard tryptone glucose extract agar is recommended. This may be obtained either from Difco Laboratories or from the Baltimore Biological Laboratories. It may also be prepared from the ingredients according to the procedure outlined by the American Public Health Association (*1*).

19. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory.

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

* This method has been approved as a tentative standard by the Standards Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the inside temperature during sterilization.

20. *Tongs.* These are necessary for handling samples of pulp.

## STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

### *1. Steam Heat (Autoclaves and Pressure Cookers)*

The following are sterilized by heating for 20 minutes at a minimum of 121°C. (249.8°F.), corresponding to 15 p.s.i. steam pressure: (a) cups and jars for disintegrators, (b) media (unless other conditions are specified by the manufacturer of the medium), (c) sample bottles, (d) corkborers, and (e) water blanks for dilution.

### *2. Dry Heat (Electrically or Gas-Heated Ovens)*

The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (329°F.): (a) heavy kraft envelopes and folders, (b) tongs, (c) knives, (d) Petri dishes, (e) pipets, and (f) scissors.

Care must be taken to dry glassware completely and to avoid overheating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

### *3. Alcohol*

Scissors, tongs, knives, and similar instruments are immersed in alcohol and dried by burning off the alcohol. When needed for cutting or handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

## TEST SPECIMEN

### *Frequency of Sampling*

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

### *Method of Sampling*

(a) *Dry Pulp.* Method A: Use either a single envelope or two sterile envelopes, one within the other, for each sample. Cut several layers of the pulp from the area to be sampled with a sterile knife. Cut these sheets larger than the sample area and discard them to eliminate any surface contamination. In the exposed area make a vertical cut with a sterile knife through several thicknesses near the center and parallel to the edge of the bale or roll; a second vertical cut parallel to the first and about 5 inches from the first cut; and a horizontal cut across the bottom of the first two cuts. Tear off and discard the top sheet of the flap, then carefully open the sterilized envelope and slip the end of the cut flap of pulp into the inner envelope. Then make a horizontal cut across the top of the flap about 6 inches from the bottom cut. The pulp sample will then drop into the inner envelope; after which, seal the outer envelope by means of a pressure-sensitive tape. Secure a sample approximately 5 by 6 inches. Take two such samples at different sections on the bale or roll.

Method B: Remove several layers of pulp by cutting with a knife. Take the corkborer from the sterile bottle and cut about $^1/_2$ inch deep into the exposed area. Replace the borer, complete with the sample core, in the bottle.

(b) *Wet Pulp.* Sample by discarding the outer surface similarly to sampling dry pulp. Transfer the samples to sterile wide-mouthed bottles by means of sterile tongs.

(c) *Slush Pulp.* The method for sampling slush stock is similar to that employed for process water and is described in T 631 m.

## PROCEDURE

### *Preparation of Sample*

(a) *Dry Pulp.* Method A: Cut the envelope in which the sample is received along the flap by means of a sterile knife or scissors. Open the envelope by pressing the sides, without touching the inner surface, and remove the dry lap with sterile tongs. Hold the sheet of pulp in one hand, trim with sterile scissors and discard the outer edges. Make a series of cuts about $^1/_4$ to $^1/_2$ inch apart, parallel to the side of the sheet, and opposite the edge held in one hand. Partially remove the cover of the tared Petri dish, but retain the cover on the pan of the balance. Cut squares of pulp directly into the dish by making a series of cuts perpendicular to those made previously.

Cut a 5.0-gram sample and make a 1% suspension of fibrous material after disintegration has been completed. Replace the cover on the Petri dish; check the weight and aseptically adjust the excess or deficiency to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

Method B: Remove the corkborer containing the sample disks from the container. Eject a 5.0-gram sample with a sterile glass rod and make a 1% suspension of fibrous material after disintegration has been completed. Replace the cover on the Petri dish; check the weight and aseptically adjust the excess or deficiency to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

(b) *Wet Pulp.* Remove the sample from the bottle by means of sterile tongs. Hold the sheet in one hand, trim with sterile scissors and discard the outer edges. Complete the preparations as for (a) Dry Pulp.

### *Disintegration*

Remove the sample from the dish and place in a disintegrator cup or jar containing enough sterile water to give a pulp consistency of 1%. In adding material to the cup, do not touch the metal cap with the hands, but lift it by grasping the paper hood which was placed over the cup before sterilizing. Lift both hood and metal cap only enough to permit access to the cup. If several pulp samples are to be examined, cool the water blanks to prevent the temperature of the disintegrated sample from exceeding 45°C. (113°F.) during disintegration. Let the paper hood remain on the cup at all times to prevent possible contamination through the opening in the metal cap or around the top of the cup.

Place the cup containing the weighed pulp sample and sterile water in a mixing machine and run until disintegration is completed.

*Plating*

Place the sample in a room which is relatively free from air currents and dust. About $^1/_2$ hour before plating, sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate, to further eliminate extraneous microorganisms.

The amount of fibrous material distributed over a given area of plate surface has been found to be an important factor in the number of colonies observed in a given sample of pulp. Therefore, it is important to follow carefully directions regarding the pulp consistency, the volume of sample used for plating (10 ml.), and the number and size of plates used.

In culturing a disintegrated pulp sample distribute with a sterile pipet a total of 10 ml. of the pulped mixture in approximately equal proportions between five Petri dishes. Plate additional dilutions if it is suspected that the pulp has a high bacterial population. Add to each plate 15 to 20 ml. of standard tryptone glucose extract agar, cooled to about 45°C. (113°F.), then agitate the plates individually to disintegrate clumps of pulp and obtain an even distribution of the fibers in the medium, using a quick, short reciprocating motion. It is important that all lumps of pulp be broken up in order that the plates may be examined easily and accurately. Pour one control plate (without pulp) from each container of medium used.

*Incubation*

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plate samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

*Counting Plate Cultures*

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If the pulp has been separated into individual fibers and well mixed with the medium, the colonies can be easily counted. If any particles are observed in the culture which cannot be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each pulp sample.

### REPORT

Results for pulp are expressed as the number of colonies per gram of wet or dry pulp examined. The consistency of the fiber suspension of such samples is 1%; thus there is present 1.0 gram of stock in each 100 grams of suspension. A total of 10 ml. of the pulped mixture (0.10 gram of actual pulp) is cultured in five plates. Therefore, to obtain the number of colonies per gram of pulp, multiply by 10 the total number of colonies found on the five plates.

In all cases record the count so that no more than two significant figures are used (*2*). For example, record a colony count of 142 as 140, and one of 145 as 150.

### LITERATURE CITED


1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 193, 9th Ed. (1946).


# Bacteriological Examination of Paper and Paperboard*

## *TAPPI Corrected Tentative Standard T 449 m-55*

**(THIS STANDARD IS UNDER THE JURISDICTION OF THE MICROBIOLOGICAL COMMITTEE)**

The following procedure is recommended for the bacteriological examination of paper and paper-board. Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well trained technician.

### APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform approximately 6 inches in diameter to readily accommodate the Petri dishes used. It should be sensitive to 0.1 gram.

3. *Corkborers.* Standard corkborers 15 to 25 mm. in diameter, used for taking samples from rolls or sheets. These are sterilized in screw-cap bottles.

4. *Bottles for Corkborers.* Screw-cap bottles large enough to hold one corkborer.

5. *Bottles for Dilution.* Several 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw caps or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

6. *Colony Counter.* Any one of several types may be used. The Quebec, the Buck, and Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

7. *Containers for Dry Samples.* When the sampling and testing are done in the same mill, a single envelope may be employed; otherwise, two single envelopes, one placed inside the other, are used. The large one may be

* This method has been approved as a tentative standard by the Standards Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

9 by 12 inches and the smaller 6.5 by 9.5 inches. They should be made of a heavy kraft paper which will withstand sterilization in the hot-air oven without embrittlement. After sterilization, the flap on the outer envelope is secured by pressure-sensitive tape.

An alternative is to make a folder of suitable size from heavy kraft paper and sterilize it in the oven. After the paper sample has been placed inside the sterile folder, the latter is sealed with the tape.

8. *Cotton.* Nonabsorbent cotton is used for plugs.

9. *Disintegrators.* Metal cup-type, with a high-speed impeller near the bottom. A kraft paper cover is placed over each disintegrator cup or jar prior to its sterilization by steam heat.

10. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp, a gasoline blow-torch, or a Bunsen burner may be used to flame tongs, scissors, knives, and the mouths of sterile containers.

11. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

12. *Incubator.* Capable of maintaining a temperature of 36 ± 1°C. (96.8 ± 1.8°F.), to provide proper incubation conditions for the inoculated plates.

13. *Knives.* A knife with an inserted blade (Stanley) may be used to cut paperboard. A paring knife with its blade cut down to within 1.5 inches of the base of the handle is also satisfactory.

14. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

15. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening of about 3 mm. in diameter at the delivery end, are best for pipetting fiber suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipet. The pipets are sterilized in metal boxes or in heavy kraft paper.

16. *Scissors.* A satisfactory type has 4-inch cutting edges.

17. *Nutrient Substrate.* Dehydrated standard tryptone glucose extract agar is recommended. This may be obtained either from Difco Laboratories or from the Baltimore Biological Laboratories. It may also be prepared from the ingredients according to the procedure outlined by the American Public Health Association (*1*).

18. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory:

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the inside temperature during sterilization.

19. *Tongs.* These are necessary for handling samples of paper.

## STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

### *1. Steam Heat (Autoclaves and Pressure Cookers)*

The following are sterilized by heating for 20 minutes at a minimum of 121°C. (249.8°F.), corresponding to 15 p.s.i. steam pressure: (a) cups and jars for disintegrators, (b) media (unless other conditions are specified by the manufacturer of the medium), (c) sample bottles, (d) corkborers, and (e) water blanks for dilution.

### *2. Dry Heat (Electrically or Gas-Heated Ovens)*

The following are sterilized by heating for at least 2 hours at a maximum temperature of 165°C. (329°F.): (a) heavy kraft envelopes and folders, (b) tongs, (c) knives, (d) Petri dishes, (e) pipets, and (f) scissors.

Care must be taken to dry glassware completely and to avoid overheating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

### *3. Alcohol*

Scissors, tongs, knives, and similar instruments are immersed in alcohol and dried by burning off the alcohol. When needed for cutting or handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

## TEST SPECIMEN

### *Frequency of Sampling*

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

### *Method of Sampling*

*Method A.* Use either a single envelope or two sterile envelopes, one within another, for each sample. Cut several layers of paper or paperboard from the area to be sampled with a sterile knife. Cut these sheets larger than the sample area and discard them to eliminate any surface contamination. In the exposed area then make a vertical cut with a sterile knife through several thicknesses near the center and parallel to the edge of the roll; a second vertical cut parallel to the first and about 5 inches from the first cut; and a horizontal cut across the bottom of the first two cuts, thus allowing the cut flap to spring out from the surface of the roll. Cut off and discard the top two sheets of the flap, then carefully open the sterilized envelope and slip the end of the cut flap of the sample into the envelope. Then make a horizontal cut across the top of the flap and about 6 inches from the bottom cut. The sample will then drop into the inner envelope; after which, seal the outer envelope by means of a pressure-sensitive tape. Secure a sample approximately 5 by 6 inches. Take two such samples at different sections of the roll.

This procedure can be adapted for sampling paper from skids, using flamed tongs for handling the samples of cut paper.

*Method B.* Remove several layers of paper or paperboard by cutting with a knife. Take the corkborer from the sterile bottle and cut about one half inch deep into the exposed area. Replace the borer, complete with the sample core, in the bottle.

## PROCEDURE

### *Preparation of Sample*

*Method A.* Cut the envelope in which the sample is received along the flap by means of a sterile knife or scissors. Open the envelope by pressing the sides, without touching the inner surface, and remove the sample with sterile tongs. Hold the sample sheets in one hand, trim with sterile scissors and discard the outer edges. Make a series of cuts about $^1/_4$ to $^1/_2$ inch apart, parallel to the side of the sheet and opposite the edge held in one hand. Partially remove the cover of the tared Petri dish, but retain the cover on the pan of the balance. Cut squares of the sample directly into the dish by making a series of cuts perpendicular to those made previously.

Cut a 5.0-gram sample and make a 1% suspension of fibrous material after disintegration has been completed. Replace the cover on the Petri dish, check the weight, and aseptically adjust the excess or deficiency to obtain sufficient sample. Weigh to an accuracy of 0.1 gram.

*Method B.* Remove the corkborer containing the sample disks from the container. Eject a 5.0 gram sample with a sterile glass rod and make a 1% suspension of fibrous material after disintegration has been completed. Replace the cover on the Petri dish, check the weight and aseptically adjust the excess or deficiency to obtain the desired weight of sample. Weigh to an accuracy of 0.1 gram.

### *Disintegration*

Remove the sample from the dish and place in a disintegrator cup or jar containing enough sterile water to give a fiber consistency of 1%. In adding material to the cup, do not touch the metal cap with the hands, but lift it by grasping the paper hood which was placed over the cup before sterilizing. Lift both hood and metal cap only enough to permit access to the cup. If several samples are to be examined, cool the water to prevent the temperature of the disintegrated sample from exceeding 45°C. (113°F.) during disintegration. Let the paper hood remain on the cup at all times to prevent possible contamination through the opening in the metal cap or around the top of the cup.

Place the cup containing the weighed sample and sterile water in a mixing machine and run until disintegration is completed.

### *Plating*

Plate the sample in a room which is relatively free of air currents and dust. About $^1/_2$ hour before plating, sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate, to further eliminate extraneous microorganisms.

The amount of fibrous material distributed over a given area of plate surface has been found to be an important factor in the number of colonies observed in a given sample of paper or board. Therefore, it is important to follow carefully directions regarding the fiber consistency, the volume of sample used for plating, and the number and size of plates used.

In culturing a disintegrated paper or board sample, distribute with a sterile pipet a total of 10 ml. of the pulped mixture in approximately equal proportions between five Petri dishes. Plate additional dilutions if it is suspected that the sample has a high bacterial population. Add to each plate 15 to 20 ml. of standard tryptone glucose extract agar, cooled to about 45°C. (113°F.), then agitate the plates individually to disintegrate clumps of fibers and obtain an equal distribution of the fibers in the medium, using a quick, short reciprocating motion. It is important that all lumps be broken up in order that the plates may be examined easily and accurately. Pour one control plate (without paper pulp) from each container of medium used.

If the sample contains a large number of bacteria, proceed as follows: Add 10 ml. of the disintegrated sample to a sterile 90-ml. water blank. Distribute 10 ml. of this dilution equally between five Petri dishes. (Plate additional dilutions if it is suspected that the sample has an extremely high bacterial population.) The total count of the five Petri dishes is a 1 : 100 dilution of the original sample.

### *Incubation*

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plated samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

### *Counting Plate Cultures*

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If the sample has been separated into individual fibers and well mixed with the medium, the colonies can be easily counted. If any particles are observed in the culture which can not be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each sample.

## REPORT

Results for paper or paperboard are expressed as the number of colonies per gram of sample examined. The consistency of the fiber suspension made of such samples is 1%; thus there is present 1.0 gram of stock in each 100 grams of suspension. A total of 10 ml. of the pulped mixture (0.10 gram of actual paper or paperboard) is cultured in five plates. Therefore, to obtain the number of colonies per gram of paper or paperboard, multiply by 10 the total number of colonies found on five plates.

In all cases record the count so that not more than two significant figures are used (*2*). For example, record a colony count of 142 as 140 and one of 145 as 150.

## LITERATURE CITED


1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association "Standard Methods for the Examination of Water and Sewage," p. 193, 9th Ed. (1946).

# Bacteriological Examination of Process Water*

## *TAPPI Corrected Tentative Standard T 631 m-55*

(THIS STANDARD IS UNDER THE JURISDICTION OF THE MICROBIOLOGICAL COMMITTEE)

THE following procedure is recommended primarily for the bacteriological examination of process water. It is also applicable to pulp slush stock. Because of the exacting technique required in bacteriological procedures, reproducible results can be secured only in the hands of a well trained technician.

### APPARATUS AND MATERIALS

1. *Alcohol.* Methyl, isopropyl, or 95% denatured ethyl alcohol is used for sterilization of instruments.

2. *Balance.* This should be equipped with a platform to readily accommodate the dilution bottles. It should be sensitive to 0.1 gram.

3. *Bottles for Dilution.* Several 8-ounce, narrow-mouthed, square-sectioned glass bottles fitted either with screw caps or with Escher rubber stoppers are used for water blanks. (Either tap or distilled water is satisfactory for dilution.)

4. *Bottles for Samples.* Several 4 to 8-ounce, wide-mouthed, glass-stoppered bottles are used for collecting samples. The type of bottle selected should be able to withstand sterilization. Prior to sterilization the stoppers and the necks of the bottles are covered with metal foil or heavy kraft paper to protect the lip of the bottle from contamination. A strip of paper may be inserted in the mouth of the bottle to prevent sticking of the stopper during sterilization.

5. *Colony Counter.* Any one of several types may be used. The Quebec, Buck, and Wolffhuegel colony counters have been found satisfactory. A hand tally for recording the count is recommended.

6. *Cotton.* Nonabsorbent cotton is used for plugs.

7. *Flaming Equipment.* Depending upon the circumstances, an alcohol lamp, a gasoline blow torch, or a Bunsen burner may be used to flame tongs, forceps, or the mouths of sterile containers.

8. *Flasks.* Erlenmeyer flasks or bottles, preferably Pyrex, may be used as containers for sterile media.

9. *Forceps.* These are used for handling slush stock of high consistency. Sterilize the forceps by flaming or by wrapping in kraft paper and sterilizing with dry heat.

10. *Incubator.* Capable of maintaining a temperature of 36 ± 1°C. (96.8 ± 1.8°F.) to provide proper incubation conditions for the inoculated plates.

11. *Petri Dishes.* Pyrex Petri dishes, 100 by 15 mm., are recommended for plating samples.

12. *Pipets.* Two sizes of pipets are used: 1.1-ml. milk-dilution type and graduated 10-ml. type. Mohr 10-ml. pipets, with tips cut off to give an opening about 3 mm. in diameter at the delivery end, are best for pipetting thick suspensions. Special Mohr pipets calibrated from the large end are available and preferable to the usual Mohr pipets. The pipets are sterilized in metal boxes or heavy kraft paper.

13. *Sampling Equipment.*

(a) Scoop. A tinsmith can make a simple scoop from a tinned iron sheet. The diameter of the scoop will depend upon the opening of the sample bottle, while the length is about 10 inches. A conveniently placed handle completes the scoop. The scoops are wrapped individually in heavy kraft paper and secured with either string or rubberbands. The unit is sterilized in a steam sterilizer.

(b) Spoon. A large spoon may be substituted for the scoop. It may be sterilized by autoclaving or at the point of use by alcohol immersion followed by flaming.

14. *Nutrient Substrate.* Dehydrated standard tryptone glucose extract agar is recommended. This may be obtained either from Difco Laboratories or from the Baltimore Biological Laboratories. It may also be prepared from the ingredients, according to the procedure outlined by the American Public Health Association (*1*).

15. *Sterilizing Equipment.* Two types are needed, the particular style and size depending upon the needs of each laboratory.

(a) A steam sterilizer, such as an autoclave or a pressure cooker.

(b) A hot-air oven. For most laboratories, electrically heated ovens are more satisfactory than those heated by gas, but the latter may be used if desired.

In both cases, thermometers are used to determine the inside temperature during sterilization.

### STERILIZATION OF EQUIPMENT AND MEDIA

Depending upon the nature of the equipment to be sterilized, use one of three methods as follows:

#### *1. Steam Heat (Autoclaves and Pressure Cookers)*

The following are sterilized by heating for 20 minutes at a minimum of 121°C. (249.8°F.), corresponding to 15 p.s.i. steam pressure: (a) media (unless other conditions are specified by the manufacturer), (b) sample bottles, (c) scoops and spoons, and (d) water blanks for dilution.

#### *2. Dry Heat (Electrically or Gas-Heated Ovens)*

The following are sterilized by heating for at least 2 hours at a minimum temperature of 165°C. (329°F.): (a) Petri dishes, (b) pipets, and (c) forceps.

Care must be taken to dry glassware completely and to avoid overheating and subsequent scorching of any paper containers or wrappers used on instruments that are being sterilized.

* This method has been approved as a tentative standard by the Standards Committee. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York, N. Y.

*3. Alcohol*

Forceps and spoons are immersed in alcohol and dried by burning off the alcohol. When needed for handling samples, remove the equipment from the liquid, let the alcohol drain off for a few moments, and then burn off the excess alcohol.

## TEST SPECIMEN

### *Frequency of Sampling*

Occasional single samples are inadequate, since the analyses reflect only the conditions which prevailed at the time when such samples were taken. The actual number of samples which should be taken depends largely on the reasons which prompt the analysis.

### *Method of Sampling*

(a) *Process Water or Low-Consistency Stock.* Use the sterile metal scoop or spoon for collecting samples of process water or stock. Dip a sample from the vat, chest or trough, using caution to avoid contamination of the sample from the hands coming in contact with the stock or from material adhering to the edges of the system. Transfer the sample to a sterile wide-mouthed bottle, replace the stopper or plug in the bottle, and retain the sample for dilution before plating.

It is frequently possible to introduce the sample directly into the bottle from a valve, faucet or pump outlet after proper flushing. Care should be taken that the sample or bottle is not contaminated by the hands during the sampling.

A simpler method of sampling may be employed in systems where there is a sufficient flow to prevent contamination. Hold the bottle by means of sterile tongs or grasp near the bottom with the hand, insert the mouth of the bottle into the flow of liquid, move the bottle into the flow, allow it to fill, remove the bottle and immediately replace its stopper.

(b) *High-Consistency Stock.* Use the sterile metal scoop or spoon for collecting the sample of slush stock. Dip a sample of the stock from the vat, chest or beater, using caution to avoid contamination of the sample from the hands coming in contact with the stock or from material adhering to the edges of the stock system. Transfer the sample to a sterile wide-mouthed bottle, replace the stopper or plug in the bottle, and retain the sample for dilution before plating.

## PROCEDURE

### *Dilution*

(a) *Process Water or Low-Consistency Stock.* In making dilutions of process water or pulp suspensions, measure 1 ml. of the sample into a sterile 99-ml. water blank and shake the mixture thoroughly. Remove the dilutions by the use of a sterile 1.1-ml. pipet. Transfer 1.0 ml. from the first water blank into a second water blank, agitate, and either dilute further or place portions in the Petri dishes. Follow this procedure until the desired dilutions have been made. It may be necessary to plate dilutions as high as 1:1,000,000; experience within a particular mill system will soon enable the bacteriologist to determine what dilution should be plated. In all cases the aim should be to obtain plate counts in the range of 30 to 300 colonies per plate.

(b) *High-Consistency Stock.* Use a sample of 10 grams of high-consistency stock to insure greater accuracy of sampling. Weigh into a tared water blank containing 90 ml. of sterile water. Shake vigorously, using 20 complete cycles of vertical motion. Further dilutions may be desired should the characteristics of the stock demand it.

### *Plating*

Plate the sample in a room which is relatively free of air currents and dust. About $^1/_2$ hour before plating, sponge the surface of the work table with a solution of a suitable toxicant, such as 5% phenol or 0.05% phenyl mercuric acetate to further eliminate extraneous microorganisms.

After the proper dilution of the process water or slush stock has been placed in Petri dishes, add approximately 15 to 20 ml. of standard tryptone glucose extract agar, cooled to about 45°C. (113°F.), to each plate. Agitate the plates with a quick, short reciprocating motion to obtain an even distribution of the pulp fibers or the water. Pour one control plate from each container of medium used.

### *Incubation*

After the plates have been agitated, place them on a flat surface until the medium solidifies; then invert and incubate the plated samples at 36 ± 1°C. (96.8 ± 1.8°F.) for 48 hours. Do not stack the plates too closely in the incubator.

### *Counting Plate Cultures*

After incubation, examine the cultures for the presence and number of bacterial colonies by holding the plates against a dark background, indirectly lighted. Plate counters are especially desirable.

If, in the case of slush stock, the individual fibers have been well mixed in the medium, the colonies can be easily counted. If any particles are observed which cannot be definitely identified as colonies, they should be examined microscopically. Plates with spreading colonies should be counted if at all possible, otherwise they should be reported as spreading colonies. Examine control plates also and make a record of the number of colonies found on the control for each sample.

## REPORT

For both process water and low-consistency stock, the results are expressed as the number of colonies per milliliter of sample examined. The results for slush stock of high consistency are expressed as the number of colonies per gram of stock examined. The number of colonies counted on the plates is multiplied by the dilution used in order to calculate the number per milliliter or per gram. In all cases record the count so that not more than two significant figures are used (*2*). For example, record a colony count of 142 as 140, and one of 145 as 150.

## LITERATURE CITED


1. American Public Health Association, "Standard Methods for the Examination of Water and Sewage," p. 186, 9th Ed. (1946).
2. American Public Health Association "Standard Methods for the Examination of Water and Sewage," p. 193, 9th Ed. (1946).

# UNITED STATES PATENTS ON PAPERMAKING

*First Quarter, 1955* — *Compiled by The Institute of Paper Chemistry*

THE following list of United States patents has been compiled from the current numbers of the Official Gazette of the United States Patent Office. Because as a rule, only one claim is published in the Gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture. Copies of any of the following patents may be obtained from the United States Patent Office, Washington 25, D. C., by sending twenty-five cents for each patent desired.

### January 4, 1955

Bathon, George H., and Whelan, Howard J. Paper widening machine. U. S. patent 2,698,645. Filed Sept. 6, 1952. 1 claim. Assigned to Oliver United Filters, Inc. [Cl. 154-42.] Two or more webs of paper are joined together lengthwise at the edges so that their width is increased proportionately without appreciable thickening at the seams.

Bitzer, Jack A. Cellulose products purification apparatus. U. S. patent 2,698,625. Filed Nov. 14, 1949. 5 claims. Assigned to General Mills, Inc. [Cl. 134-63.] Cellulose sponge articles are conveyed to chemical and water bath treatment stations, under which catch basins are located to recover the solutions used.

Goepfert, Otto F., and Landeck, Richard W. Cigarette paper booklet packing device. U. S. patent 2,698,706. Filed Sept. 13, 1951. 10 claims. Assigned to Ecusta Paper Corp. [Cl. 226-14.]

Greenman, Norman L., and Berry, Richard C. Rubberized fibrous sheet and method of making the same. U. S. patent 2,698,788. Filed Feb. 27, 1952. 11 claims. Assigned to Rogers Corp. [Cl. 92-3.] Steps comprise beating a mixture of mineral fiber and uncured rubber in latex form, water, and a phenolic resin; precipitating the rubber and resin on the mineral fibers and sheeting out, dewatering, drying and calendering the material in the usual manner to form a fibrous sheet.

Harkess, William L. Apparatus for setting up cartons. U. S. patent 2,698,559. Filed Aug. 28, 1948. 16 claims. Assigned to Package Machinery Co. [Cl. 93-53.] Collapsed tubular ice cream or butter cartons are automatically distended and set up with one end left open to receive the contents.

Harper, Fred C. Pulp forming mold. U. S. patent 2,698,557. Filed June 27, 1951. 2 claims. Assigned to Keyes Fibre Co. [Cl. 92-54.] A screen-covered, pulp forming mold, anchoring device has pneumatic passageways for slurry drainage; the screening cover assures a pulp layer without appreciable formation variations.

Hawley, Don M., and Williams, John C. Method of preparing felted products containing glass fibers. U. S. patent 2,698,558. Filed Jan. 17, 1952. 12 claims. Assigned to Hawley Products Co. [Cl. 92-55.] Glass filament bundles, in combination with a thermosetting fusible polyester resin, are cured in an aqueous slurry heated to a temperature of 160°F.

Horst, William P., ter. Self-extinguishing composition of cellulose acetate and benzene hexachloride. U. S. patent 2,698,806. Filed Dec. 28, 1951. 6 claims. Assigned to Olin Mathieson Chemical Corp. [Cl. 106-15.] A composition of matter consists essentially of cellulose acetate and from 1% by weight to the limit of compatibility of benzene hexachloride.

Landes, Chester G., and Reynolds, Walter F., Jr. Sized paper comprising a polymerized alkylenimine. U. S. patent 2,698,793. Filed April 11, 1952. 15 claims. Assigned to American Cyanamid Co. [Cl. 92-21.] The alkylenimine resins formed by the self-polymerization of ethylenimine, propylenimine, or butylenimine may be used with certain alkaline sizing agents to impart improved ink and water resistance to paper. The combination is apparently synergistic and the cause of sizing is not known. After the addition of alkylenimine resin and sizing agent to the pulp the pH is raised to 10, and fillers such as calcium carbonate may be added at this stage.

Margolies, Morton J. Multicompartment carton and package. U. S. patent 2,698,708. Filed Oct. 1, 1951. 2 claims. [Cl. 229-28.]

Moody, Eddie L. Automatic papercutter. U. S. patent 2,698,662. Filed May 14, 1951. 12 claims. [Cl. 164-73.] A tail cutting device is adapted in the winding operation to sever and transfer a traveling paper web from a full roll to an empty core.

Neuman, Elmer A. Collapsible container. U. S. patent 2,698,709. Filed Aug. 22, 1951. 4 claims. [Cl. 229-32.] A fiberboard shipping container has separately collapsible top and bottom sections which are mutually reinforced in setup position.

Segl, Walter E. Method for the digestion of cellulose-bearing material. U. S. patent 2,698,789. Filed Feb. 8, 1954. 11 claims. Assigned to Hercules Powder Co. [Cl. 92-6.] The difficulty of high "pill count" encountered in compacted cellulosic materials is overcome in a digestion method whereby wetted cellulose is gathered and passed by a double flight screw for subsequent compression and disintegration operations.

Schiller, Arthur M., and Suen, Tzeng J. Urea-formaldehyde resins for wet strength paper and their use. U. S. patent 2,698,787. Filed Dec. 17, 1951. 8 claims. Assigned to American Cyanamid Co. [Cl. 92-3.] A urea-formaldehyde resin formulation is given in which one of the constituents is a monosubstituted urea containing an aminoalkyl radical. Using the proper amount of aminoalkyl urea, the wet-strength resin may be acidified without precipitation.

Strong, Allen K. Shipping unit and lifting skid therefor. U. S. patent 2,698,696. Filed Dec. 24, 1953. 6 claims. Assigned to American Cyanamid Co. [Cl. 214-10.5.] A double-thick kraft paper skid with lifting tubes incorporated in each end, is capable of supporting loads up to $^3/_4$ ton to be fork-lifted as one unit.

### January 11, 1955

Bell, Kenneth, and Fisher, Guy N. Packaging. U. S. patent 2,699,285. Filed May 5, 1950. 2 claims. Assigned to Kraft Foods Co. [Cl. 229-51.] A tear tape is incorporated in a heat-sealed cellophane-type cheese wrapper in such a manner that, when pulled, the tape tears the wrapper only along the lines defined by the tape.

Bock, Louis H., and Anderson, James K. Linear polyesters of carboxy-2-hydroxymethylbenzodioxane. U. S. patent 2,699,438. Filed April 19, 1952. 8 claims. Assigned to Rayonier Inc. [Cl. 260-78.3.] In an inert atmosphere at 200–300°C. the condensation of carboxy-2-hydroxymethyl-1,4-benzodioxane yields a linear polymer. The hydroxy acid may be prepared by reacting protocatechuic acid, obtainable from spent sulphite liquor, with epichlorohydrin.

Binkley, Mark E. Method of manufacture of heat insulating shapes. U. S. patent 2,699,097. Filed March 20, 1953. 10 claims. Assigned to Johns-Manville Corp. [Cl. 92-55.] The process involves the formation of a dilute aqueous slurry suspension of reactive proportions of diatomaceous silica and lime with mineral reinforcing fibers.

Crandall, Henry C. Reinforced paper and method of making same. U. S. patent 2,699,389. Filed July 26, 1951. 6 claims. Assigned to Mosinee Paper Mills Co. [Cl 92-3.] A flexible reticular mesh of thermoplastically bonded glass fibers are interpenetrated with and covered by a felted web of paper fibers, the bonding agent (asphalt or polyamide resins) secures the mesh strands to each other and to the adjoining web fibers.

De Villers, Edmund J. Paper cap-forming apparatus. U. S. patent 2,699,274. Filed March 26, 1952. 10 claims. Assigned to White Castle Systems, Inc. [Cl. 223-7.]

Francis, Carleton S., Jr. Meat-wrap process and product. U. S. patent 2,699,396. Filed Jan. 4, 1951. 15 claims. Assigned to Lamitex Products, Inc. [Cl. 99-174.] A skin-like moist covering for meat carcasses which retains the optimum amount of juices in the meat during chilling, storage, and shipment comprises a wrap having an absorptive (paper) surface and a nonabsorptive (cellophane) surface.

Geffroy, Georges. Closure for bags and pouches. U. S. patent 2,699,286. Filed Nov. 7, 1950. 1 claim. Assigned to La Cellophane. [Cl. 229-62.] A tear tape is incorporated in the sealing strip adhered to the folded-over top edges of a paper bag or cellophane-type sack.

Hedin, Börje V. Press-plate for wallboard presses and the like. U. S. patent 2,699,325. Filed Sept. 27, 1950. 1 claim. [Cl. 257-256.] A fluid-circulation platen for presses comprises two

channeled outer sections abutting at least one channeled intermediate section; the conduits are bored in such a manner that a minimum of plugs is required.

Hornbostel, Lloyd. Rectifier roll assembly. U. S. patent 2,699,096. Filed April 10, 1953. 6 claims. Assigned to Beloit Iron Works. [Cl. 92-44.] Offsetting the perforations in rectifier rolls and radial baffles in adjacent rolls results in improved stock flow control.

Irwin, Russel D. Control apparatus for pulp refiners. U. S. patent 2,699,095. Filed Nov. 10, 1953. 12 claims. Assigned to Minneapolis-Honeywell Regulator Co. [Cl. 92-27.] The grinding operation is automatically controlled by the temperature rise of the pulp as it passes through the grinder; the temperature signal is reset in accordance with the freeness of the final pulp.

Johannsen, Adolf, Danz, Willi, Fees, Karl, and Kammerer, Walter. Production of gases containing sulfur dioxide. U. S. patent 2,699,375. Filed March 13, 1951. 5 claims. Assigned to Badische Anilin- & Soda-Fabrik Aktiengesellschaft. [Cl. 23-177.] This patent relates to the design of a furnace for roasting pyrites in such a manner that high throughput can be maintained without agglomeration. The use of Field tubes enables accurate temperature control, critical for the success of the method.

Lee, Glen M., and Olson, Raymond J. Locking means for the stakes of logging bunks. U. S. patent 2,699,340. Filed Dec. 1, 1953. 3 claims. [Cl. 280-145.]

Lockman, Carl J. Circulation of digestion liquor in sulphite pulp boiling. U. S. patent 2,699,390. Filed Feb. 17, 1954. 4 claims. Assigned to Aktiebolaget Rosenblads Patenter. [Cl. 92-7.] Digestion liquor, containing scale-forming calcium sulphate, is caused to flow through the heat exchanger in alternately reverse directions so that during each period of through-flow, nonsaturated digestion liquor dissolves the plaster incrustations formed during the preceding period.

Lyons, Herbert R. Method and apparatus for forming paper sticks or the like. U. S. patent 2,699,098. Filed April 25, 1952. 15 claims. Assigned to The Diamond Match Co. [Cl. 93-1.]

Lyons, Herbert R. Wetting device for paper handling machines. U. S. patent 2,699,142. Filed Dec. 30, 1952. 6 claims. Assigned to The Diamond Match Co. [Cl. 118-267.] Curled paper sheets or sticks are passed over a porous metal plate which is wetted by liquid supply means.

Marra, William H., and Stinchfield, John C. Paper coating compositions comprising an adhesive, an alkali metal silicate, and an attapulgite or zeolite material. U. S. patent 2,699,432. Filed May 26, 1951. 1 claim. Assigned to The National Cash Register Co. [Cl. 260-29.6.] Use is made of the ion-exchange properties of attapulgite as a surface-active agent with acidic adsorption characteristics. When suitably coated on paper, the material reacts with a printing ink containing crystal violet lactone to give a deep blue mark at the point of impression.

McGarvey, John A., and Adamick, Jules R. Air blast means for buckle-type blank folding machines. U. S. patent 2,699,331. Filed June 11, 1952. 1 claim. [Cl. 270-68.] The mechanism forms a fold dividing the body portion of the blank into two parts and concurrently tucks the gates into the fold between the two parts.

McLeod, Donald A. Debarking tool. U. S. patent 2,699,189. Filed Oct. 5, 1951. 12 claims. [Cl. 144-208.] The tool comprises a shoe element arcuated in general correspondence with the periphery of a tree member.

Morin, George V. N. Waterproof disposable diaper. U. S. patent 2,699,170. Filed May 5, 1954. 5 claims. Assigned to Chicopee Manufacturing Corp. [Cl. 128-287.] A thin permeable facing sheet joined to an embossed polyethylene laminated paper backing sheet forms a flexible waterproof envelope for the filler of the diaper.

Repsher, Leonard, and Pedicini, Salvador. Paper-covered aluminum assembly for bonding to plywood. Filed May 6, 1949. 9 claims. Assigned to Union Carbide and Carbon Corp. [Cl. 154-129.] A plywood structure comprises an aluminum sheet barrier, paper bonded with a solvent solution of a thermosetting phenol-formaldehyde resin.

Robinson, Ernest B. Apparatus for producing helically wound cylinders. U. S. patent 2,699,099. Filed May 29, 1952. 11 claims. [Cl. 93-80.]

Schur, Milton O. Apparatus for forming perforated tea bag paper. U. S. patent 2,699,208. Filed Sept. 13, 1950. 6 claims. Assigned to Ecusta Paper Corp. [Cl. 164-99.]

Selbe, Rexford L. Water-resistant gypsum composition and emulsions for making the same. U. S. patent 2,699,414. Filed Dec. 28, 1951. 6 claims. Assigned to United States Gypsum Co. [Cl. 154-45.9.] An emulsion suitable for waterproofing paper-covered sheathing board comprises a blend of oil-soluble alkali salts of mahogany sulphonic acid with asphalt and paraffin wax. The latter two, in the proportion from 2:1 to 10:1, are dispersed in an aqueous solution of an alkalinized water-soluble protein and contain about 0.5–4% of the trisodium salt of a trinapthalene-dimethylene trisulphonic acid.

Wollett, Ernest S. Sandwich wrapping machine. U. S. patent 2,699,022. Filed Nov. 24, 1948. 35 claims. [Cl. 53-131.] The device provides means for wrapping and sealing triangular cut sandwiches in thermoplastic wrappers.

### January 18, 1955

Baum, Arthur A., and Sanders, Paul A. Fluorescent whitening agents. U. S. patent 2,700,043. Filed March 26, 1953. 8 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 260-304.] A series of aromatic triazoles containing one or two sulphamyl radicals is described for use as whitening agents on textiles and cellulose fibers. Bleach resistance, water solubility, and high fluorescence are claimed.

Breuning, Ernst W., Karpinski, Hans J., and Mörike, Heinrich O. Process and device for shaking the forming wire of fourdrinier machines. U. S. patent 2,699,709. Filed June 6, 1951. 9 claims. Assigned to Papierfabrik Scheufelen. [Cl. 92-45.] The wire cloth is shaken by direct movement of electro-dynamic forces; the amount of shake is controlled by adjustment of the field intensity of the magnet.

Carlson, Arthur E., and Baxter, Joe, Jr. Apparatus for producing reinforced sheet material. U. S. patent 2,699,813. Filed Aug. 14, 1950. 20 claims. Baxter's interests assigned to Carlson. [Cl. 154-1.76.] An apparatus is claimed, which produces the reinforced sheet material disclosed in U. S. patent 2,610,936 (Sept. 16, 1952).

Couch, Robert de S., and Muldoon, Thomas J. Impact fatigue testing of packaging materials and containers. U. S. patent 2,699,672. Filed Oct. 27, 1950. 5 claims. [Cl. 73-12.] Filled kraft or glassine paper bags, or light containers are tested in actual field usage.

Meyer-Jagenberg, Gunther, Drese, Wilhelm, and Welsch, Hans. Method and mechanism for unfolding, refolding, setting-up, and transporting cartons in spaced relationship. U. S. patent 2,699,712. Filed Nov. 19, 1953. 13 claims. Assigned 50% to Jagenberg-Werke Akt.-Ges. [Cl. 93-53.]

Mobley, Edwin H. F. Carton erecting machine. U. S. patent 2,699,711. Filed Sept. 15, 1951. 15 claims. Assigned to Bloomer Bros. Co. [Cl. 93-37.] Collapsed cellular egg cartons are withdrawn from a supply hopper and are set up by continuously rotating devices within the machine.

Morton, Avery A. Method of treating waste sulfite liquors. U. S. patent, 2,699,998. Filed Jan. 7, 1948. 3 claims. Assigned to Penobscot Chemical Fibre Co. [Cl. 106-123.] A major portion of the dissolved solids in spent sulphite liquor may be separated by addition of a water-soluble aliphatic alcohol. When sufficient alcohol has been added an immiscible solution results; this consists of an aqueous-solids fraction and an aqueous-alcohol fraction.

Nigrelli, Biagio J. Labeling device. U. S. patent 2,699,881. Filed July 31, 1953. 10 claims. Assigned to Nekoosa-Edwards Paper Co. [Cl. 216-35.] Means are provided for supporting and applying labels to the ends of packaged reams of paper.

Sartori, Mario F. Compounds of the benzimidazolyl-phenyl-1,2-naphthotriazole type, useful as whitening agents. U. S. patent 2,700,044. Filed March 6, 1953. 8 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 260-308.] The preparation and properties of a number of blue fluorescent compounds are given. Water solubility and good bleach fastness are claimed, as well as a high degree of fluorescence. Essentially the same as U. S. patent 2,700,043.

Vahle, Raymond. Carton erecting machine. U. S. patent 2,699,710. Filed Aug. 1, 1950. 2 claims. Assigned to Robert Gair Co., Inc. [Cl. 93-37.] A division of U. S. patent 2,642,196 (June 16, 1953). This patent is related to the stacker unit in which erected cellular egg cartons are stacked in internested relation.

Wandel, Kurt. Process of preparing mulch for agricultural purposes. U. S. patent 2,699,629. Filed Aug. 10, 1950. 6 claims. Assigned to Wilbro Corp. [Cl. 47-9.] Refuse, containing organic material and waste paper is subjected to mechanical disintegration so that the paper is separated into its constituent fibers and the mulch becomes odor free and no longer subject to putrefaction.

Wittkuhns, Bruno A., and Hill, Gilbert F. Machine for coating containers. U. S. patent 2,699,750. Filed April 26, 1951. 13 claims. Assigned to National Paper Bottle Co., Inc. [Cl. 118-52.] The apparatus includes a conveyer with receiving baskets for continuously dipping paper containers (milk) in and out of a paraffin bath.

### January 25, 1955

Anspacher, Edgar. Mattress package and method of wrapping. U. S. patent 2,700,459. Filed May 27, 1949. 4 claims. [Cl. 206-46.] A multilayer paper wrapper has sealing seams distributed around the periphery of the mattress.

Arneson, Edwin L. Article carrier. U. S. patent 2,700,486. Filed Jan. 13, 1951. 7 claims. [Cl. 220-105.] A retractable-

handled paperboard can carrier may be assembled by standard gluing and folding apparatus.

Claus, Paul E. Device for applying closures to containers. U. S. patent 2,700,328. Filed July 23, 1951. 10 claims. Assigned to Gaylord Container Corp. [Cl. 93-39.1.] Pilfer-proof and nonremovable closures are applied to octagonal fiberboard shipping containers.

Curtis, Russell H. Method and apparatus for making accreted fibrous tubular bodies. U. S. patent 2,700,326. Filed July 29, 1949. 4 claims. Assigned to Hawley Products Co. [Cl. 92-57.] The forming mechanism shapes the exterior of the fibrous object, without trimming, so that there is uniformity of cross-section and top to bottom density.

Dungler, Julien. Drying or like treatment apparatus for web materials with fluid deflecting baffle means. U. S. patent 2,700,-226. Filed Sept. 2, 1950. 16 claims. [Cl. 34-160.] Spaced discharge nozzles, through which drying fluid is directed, prevent lateral displacement of the web while it is guided substantially tensionless through the drier.

Durand, Yves. Folding box for a plurality of similar objects. U. S. patent 2,700,499. Filed June 19, 1951. 4 claims. [Cl. 229-28.] A six-celled shockproof carrier for glassware can be articulated from a cardboard blank.

Foster, William J. Bellows folding machine. U. S. patent 2,700,327. Filed Sept. 12, 1949. 33 claims. Assigned to General Motors Corp. [Cl. 93-1.] The mechanism for forming and then pleating a paper tube is very similar to that claimed in U. S. patent 2,696,768 (Dec. 14, 1954).

Goldberg, Nathan, and Goldberg, Jacob M. Shipping container. U. S. patent 2,700,485. Filed Feb. 2, 1952. 3 claims. [Cl. 220-80.] A shipping and storage fiberboard container for moving picture film reels is assembled and reinforced by prefabricated metal strips.

Lourd, Jacques L. J. Process for degumming vegetable textile fibers. U. S. patent 2,700,608. Filed Dec. 21, 1951. 4 claims. Assigned 50% to Société d' Exploitation des Procedes Lourd. [Cl. 92-10.] The fibers are subjected to the simultaneous action of an aqueous solution of a wetting agent, 0.001–1.0% of sulphoricinoleic acid, lauryl sulphuric acid and ethyl-pyridinium bromide and an acid solution containing 0.2–2.0% of an acid selected from sulphuric and hydrochloric acid groups and in which the wetting agent is stable, and then rinsing and drying the fibers.

Mottet, Arthur L. Method and apparatus for making fiberboard with prepressed margins. U. S. patent 2,700,177. Filed March 29, 1954. 9 claims. Assigned to The Long-Bell Lumber Co. [Cl. 18-4.] Lignocellulose is formed into a mat, is compressed along the longitudinal margins (the lignocellulose then removed from the surface of the mat between the margins) and heat consolidation is applied.

Poston, Blanch, and Bell, Jerome. Disposable type umbrella. U. S. patent 2,700,390. Filed June 6, 1949. 11 claims. [Cl. 135-20.] A water-resistant paper canopy has attached ribs which telescope into the handle.

Schwalbe, Hellmuth, C., Hydell, Robert C., and O'Connor, James J. Manufacture of coated paper and product. U. S. patent 2,700,621. Filed Jan. 6, 1950. 7 claims. Assigned to The Mead Corp. [Cl. 117-65.] In a method of coating printing paper, including a supercalendering step and using the roll coating apparatus described in U. S. patent 2,565,260 (Aug. 21, 1951), finely divided finish imparting mineral coatings are applied to the paper in the form of aqueous suspension with high solids content yet low MacMichael viscosities.

Somers, Arthur V. Roller machine and method for impregnating web material. U. S. patent 2,700,620. Filed Dec. 6, 1949. 9 claims. Assigned to General Motors Corp. [Cl. 117-60.] A pan of applicator rolls, co-operating with a pair of measuring rolls, apply a coating compound of measured thickness to the paper web.

Sullivan, James E., and Kenneway, Harold J., Jr. Decalcomania paper. U. S. patent 2,700,619. Filed Oct. 9, 1951. 5 claims. Assigned to McLaurin-Jones Co. [Cl. 117-3.6.] The water-activitable adhesive coating comprises 5% by dry weight of dimethyl hydantoin formaldehyde and 5–25% by weight of sodium cellulose sulphate.

### February 1, 1955

Buttery, Kenneth T. Covered collapsible triangular carton. U. S. patent 2,701,090. Filed April 3, 1950. 1 claim. Assigned to Sutherland Paper Co. [Cl. 229-22.] A container for pie wedges or similarly shaped bakery goods is claimed.

De Noyer, Donald B. Method and apparatus for applying a wire to Fourdrinier machines. U. S. patent 2,700,921. Filed Dec. 23, 1950. 2 claims. Assigned to Valley Iron Works Co. [Cl. 92-44.]

Fischer, Howard J. Carton construction. U. S. patent 2,701,089. Filed July 26, 1951. 5 claims. Assigned to The United States Printing & Lithograph Co. [Cl. 229-16.] A preformed blank for folding into a container for displaying crayons, has a sloping double false bottom which holds each row of crayons higher than the row in front.

Klasing, Arthur P. Automatic sheet feeding, positioning, punching, and cutting machine. U. S. patent 2,701,013. Filed March 19, 1951. 3 claims. Assigned to Gaylord Container Corp. [Cl. 164-12.] Automatic positioning means, comprising an automatic trimmer and feeder, work in combination with a ram, a tapering knife and a cutoff knife. Each downward stroke of the device produces one finished piece (paperboard cellular partitions, or the like).

Roman, Charles. Method of and means for making artificial wood products. U. S. patent 2,700,796. Filed Sept. 14, 1950. 5 claims. [Cl. 18-42.] Pressed board is manufactured by agitating wood waste in a mixer with a mist of a thermosetting binder until dampened, then formed and precipitated and heat and pressure cured. The top face of the mass is contacted by a polished metallic surface while a foraminous bottom plate permits the escape of steam.

Sullivan, Frank N. Container. U. S. patent 2,701,091. Filed Oct. 1, 1949. 2 claims. Assigned to Kraft Foods Co. [Cl. 229-23.] The cardboard container for processed cheese may be passed through the usual filling machinery without deforming the box.

Tamarin, Bernard J. Cigarette package with pull strip. U. S. patent 2,701,053. Filed Feb. 3, 1947. 8 claims. Assigned to Pull-Packaging, Inc. [Cl. 206-41.2.] A pull-strip attached to the outer (cellophane) wrapper permits the opening of the inner wrapper as well as the partial withdrawal of a single cigarette from the package.

Tyrseck, Walter J. Carton. U. S. patent 2,701,088. Filed June 10, 1949. 4 claims. Assigned to Robertson Paper Box Co. Inc. [Cl. 229-14.] A cardboard bottle container blank has an inner sleeve construction which supports and cushions the bottles in setup position.

Vander Lugt, Thomas, Jr. Collapsible partitioned carton. U. S. patent 2,701,076. Filed Oct. 29, 1951. 14 claims. Assigned to Sutherland Paper Co. [Cl. 220-111.] The assembly of a six-celled bottle carton blank is easily effected by simple gluing and folding steps.

### February 8, 1955

Bishop, Thomas D. Apparatus for slotting cardboard and the like for the manufacture of boxes. U. S. patent 2,701,613. Filed April 2, 1952. 9 claims. Assigned to The Deritend Engineering Co. Ltd. [Cl. 164-60.]

Dovberg, Maurice S., and Dovberg, Ike. Wall size to be added to a ready-mixed wallpaper paste. U. S. patent 2,701,773. Filed April 15, 1953. 1 claim. [Cl. 106-157.] The preparation increases the density of the wallpaper paste and provides an effective filler for the pores of the wall surface and of the paper.

Gazette, Marshall E. Method of mounting a bottom wall in cylindrical containers. U. S. patent 2,701,506. Filed Feb. 10, 1954. 1 claim. [Cl. 93-55.1.] Two rings are adhesively beaded and rested to fit within the end of the cylindrical wall member as the support for the disk which is to be the bottom of the container.

Goldstein, Saul. Dispensing container. U. S. patent 2,701,-679. Filed Oct. 15, 1952. 2 claims. [Cl. 229-17.] A cardboard milk container and pouring spout may be formed from a single scored and cut sheet.

Grammer, Allen L. Container for papers, notes, and the like. U. S. patent 2,701,677. Filed April 13, 1951. 1 claim. [Cl. 229-16.]

Murray, Arthur J. Carrier for canned or bottled goods. U. S. patent 2,701,661. Filed Nov. 30, 1951. 2 claims. Assigned to Rapid-Rap, Inc. [Cl. 220-113.]

Read, Arthur. Pouring spout for cartons. U. S. patent 2,701,678. Filed Nov. 12, 1949. 1 claim. Assigned to Floseal Corp. [Cl. 229-17.] A cardboard blank insert may be folded over on itself and secured to the interior of two adjoining walls of a (milk) carton to form a sanitary, resealable spout.

Sivola, George. Process of manufacturing pulp from cellulosic fibrous materials. U. S. patent 2,701,763. Filed Nov. 6, 1947. 9 claims. [Cl. 92-13.] A three-phase, acid-alkali cooking operation is described which is capable of producing pulp which is as white as ordinary calcium-base sulphite pulp.

Snyder, Posey R. Wallboard trimmer. U. S. patent 2,701,-416. Filed June 12, 1953. 5 claims. [Cl. 30-293.] A phase-type device incorporates a blade-adjustment assembly which can be preset to recess the wallboard edges to the desired depth without tearing the paper surface of the wallboard.

Weisheimer, Carl H. Carrying handle and closure for paper bags. U. S. patent, 2,701,680. Filed Aug. 3, 1950. 2 claims. [Cl. 229-62.] A cardboard handle is adapted to grip the multiple folds of the open end of a paper flour bag, thus increasing the carrying strength of the bag and facilitating its handling.

### February 15, 1955

Baumann, Martin. Shipping package. U. S. patent 2,702,-155. Filed July 27, 1950. 1 claim. Assigned to International Paper Co. [Cl. 229-52.] A reusable, collapsible shipping container (bottles) has 5-ply strength at the upper side edges due to integration of the closure flaps with the side walls.

Biggs, William A., Jr., and Adams, William S. Yarn package. U. S. patent 2,702,167. Filed Nov. 3, 1951. 3 claims. Assigned to Sonoco Products Co. [Cl. 242-161.] A paper, conical yarn carrier is provided with a flock coating which holds multifilament synthetic yarns on the cone surface without slippage while it allows the inner windings to be delivered.

Britton, Richard K. Reclosable container. U. S. patent 2,702,152. Filed Jan. 23, 1951. 10 claims. Assigned 50% to Ex-Cell-O Corp. and 50% to Ace Carton Corp. and Ace C. Fessenden. [Cl. 229-17.] A container (milk) has a leakproof, reclosable flap which seals the pouring opening.

Fergnani, Walter P. Box blank folding machine. U. S. patent 2,701,990. Filed Aug. 30, 1951. 4 claims. Assigned to Post Machinery Corp. [Cl. 93-52.]

Forrer, Homer W. Bottle carrier. U. S. patent, 2,702,144. Filed May 15, 1950. 7 claims. Assigned to Atlanta Paper Co. [Cl. 220-111.]

Guver, Reynolds. Egg case. U. S. patent 2,702,151. Filed Jan. 2, 1951. 4 claims. Assigned to Waldorf Paper Products Co. [Cl. 229-15.] A partitioned, corrugated board egg case has outer wall shells connected together in tubular form without requiring the use of a stitch lap or securing tape.

Hawley, Don M., and Williams, John C. Glass fiber material. U. S. patent 2,702,241. Filed Oct. 7, 1950. 9 claims. Assigned to Hawley Products Co. [Cl. 92-3.] A polyvinyl acetate and a plasticizer (e.g., tricresyl phosphate, dibutyl phthalate) is used to coat twisted glass filaments in bundles in an aqueous slurry before felting, and sheeting and/or molding operations.

Hayward, Claude E., and Gorton, Edward S. Apparatus for forming tubing for bags or the like. U. S. patent 2,701,989. Filed May 14, 1952. 1 claim. Assigned to Bemis Bro. Bag Co. [Cl. 93-20.] A tuber is provided with inside former blades, which are thin enough to form the gusseted tubing and still reduce friction enough to eliminate overheating the coating or laminate, thus preventing rupture of the moistureproof liner.

Hochmuth, Frank W. Chemical ash dissolving tank for black liquor recovery units. U. S. patent 2,702,235. Filed March 20, 1951. 2 claims. Assigned to Combustion Engineering, Inc. [Cl. 23-262.] In the temperature-activated pneumatic control method claimed, the "batch" system of chemical recovery from the fly ash carried in combustion gases is replaced by a continuous self controlling and semiautomatic recovery method.

Hollis, Robert F. Cylinder papermaking machine. U. S. patent 2,701,988. Filed June 4, 1951. 2 claims. Assigned to Alton Box Board Co. [Cl. 92-43.] A feed box is claimed which introduces the stock uniformly across the entire width of the machine with no segregation of the stock in the feed box.

Lillis, Stephen M., and Toman, John C. Process of recovering treated fibrous material. U. S. patent 2,702,162. Filed March 29, 1952. 5 claims. Assigned to Victor Manufacturing & Gasket Co. [Cl. 241-14.] Treated asbestos fibers from waste gasket sheets is subjected to pulverizing, aerating, slurry-forming, decanting and settling steps.

Linson, Don A. Self-erecting box with locking bottom. U. S. patent 2,702,154. Filed May 22, 1952. 3 claims. Assigned to Paper Package Co. [Cl. 229-39.] A prefolded cardboard blank is provided with bottom-locking lugs which are protected from deformation until the blank is assembled into a slope-sided box for packaging berries or the like.

Murray, Arthur J. Method and apparatus for packaging cans and bottles in carrier cartons. U. S. patent 2,701,938. Filed Nov. 30, 1951. 12 claims. [Cl. 53-7.] A plurality of interconnected jigs in the mechanism claimed continuously wrap the articles in two-row position and simultaneously form the carrier carton.

Paasche, Bertha. Figure display. U. S. patent 2,702,148. Filed Aug. 4, 1951. 6 claims. [Cl. 223-68.] A female display form (mannikin) may be set up from a precut, scored and folded sheet of cardboard or similar material so that one portion may be adjusted or varied with respect to the other.

Spooner, Laurence W. Aluminum phosphate bonded asbestos insulating material. U. S. patent 2,702,068. Filed Feb. 13, 1953. 7 claims. Assigned to General Electric Co. [Cl. 154-2.6.] Machinable, high-temperature electrical insulation, consists of five asbestos sheets individually impregnated with monoaluminum phosphate and bonded together.

Van Rosen, Robert E. Corner lock box. U. S. patent 2,702,-153. Filed Jan. 20, 1951. 2 claims. Assigned to The Gardner Board and Carton Co. [Cl. 229-35.] U-shaped tabs interlock and reinforce the cardboard box walls in setup position.

Welsh, Ormonde P. Envelope stacking mechanism. U. S. patent 2,702,190. Filed Dec. 29, 1950. 11 claims. Assigned to Parten Machinery Co. [Cl. 271-87.] The rugged and durable machine claimed, of low reciprocating inertia can accommodate envelopes of minor size variations and movement aberrations without interfering with operation of the parts.

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Acker, Ralph E. Compartmented shipping container. U. S. patent 2,702,661. Filed Oct. 6, 1951. 2 claims. Assigned to Container Corp. of America. [Cl. 229-15.]

Barth, Eugene I. Method of applying metallic stripes to a web of paper. U. S. patent 2,702,760. Filed April 25, 1951. 8 claims. Assigned to Western Electric Co., Inc. [Cl. 117-38.] A vaporized silver, copper, or nickel coating is sputtered on a strip of insulating material (paper precoated with cellulose acetate butyrate) to form such articles as condenser components or the like.

Crawford, James H. Lock bottom box. U. S. patent 2,702,-662. Filed Oct. 26, 1951. 1 claim. Assigned to Fort Wayne Corrugated Paper Co. [Cl. 229-16.] A corrugated board blank has rectangular panels so arranged, scored and separated as to make the box bottom locked and double-walled throughout.

Donaldson, Edwin S. Combined holder and opener for containers. U. S. patent 2,702,660. Filed Dec. 1, 1951. 5 claims. [Cl. 229-7.] The device, suitable for opening and holding rectangular cardboard boxes (washing powders) comprises a lever means which locks the holder in position.

Freeland, John W. Drilling fluid. U. S. patent 2,702,787. Filed Aug. 22, 1950. 8 claims. [Cl. 252-8.5.] A pressure and temperature-resistant drilling fluid, characterized as a water-in-oil emulsion, contains a minor proportion of water and a major proportion of a petroleum distillate of low viscosity. The emulsion is stabilized by sodium carboxymethyl cellulose and an oil-soluble calcium soap (calcium tall oil or calcium rosin soaps in examples given). The aqueous phase of the emulsion contains sufficient calcium hydroxide to bring the pH to a range of 10–14.

Hipp, Norbert J., Groves, Merton L., and McMeekin, Thomas L. Separation of alpha-, beta-, and gamma-caseins from whole starch. U. S. patent 2,702,800. Filed July 14, 1952. 9 claims. Assigned to United States of America as represented by the Secretary of Agriculture. [Cl. 260-120.] Fractionated, homogeneous casein, valuable for studies on physical, chemical, or nutritional properties is obtained by dissolving whole casein in aqueous solution (containing a urea concentration sufficient to obtain solution). The resulting solution is subjected to steps of removing precipitated alpha-, beta-, and gamma-casein.

Klein, Stanley J. Nested carton blank. U. S. patent 2,702,-663. Filed April 16, 1952. 1 claim. Assigned to Empire Box Corp. [Cl. 229-31.] A pair of double-walled carton blanks has sawtoothed outer panels which allow the blanks to nest so that when the blanks are cut, a single die element at one line will separate the two cut blanks at their adjoining edges without waste.

Mannheim, Carl P. Method of impregnating fiber insulation board. U. S. patent 2,702,761. Filed July 12, 1949. 4 claims. Assigned to The Celotex Corp. [Cl. 117-43.] Roofing and siding boards are made by a process which includes the steps of preheating the fiber sheet, immersing the board in an asphaltic saturating bath (while the preheated portions of the board are still heated). Finally the sheet is subjected to a surface squeegeeing operation and suitable cooling to solidify the asphaltic saturant.

Newsom, Kitchener K. Pallet. U. S. patent 2,702,682. Filed April 23, 1951. 4 claims. [Cl. 248-120.] A lightweight, inexpensive knockdown freight shipping pallet comprises a fiberboard platform mounted on a cross slot frame and nine legs, each formed of heavy paper strip fanfolded under compression.

Perry, Eugene L. Paper machine. U. S. patent 2,702,497. Filed June 22, 1949. 3 claims. Assigned to Packaging Materials Corp. [Cl. 92-43.] Improvements in cylinder and suction box construction allow an increased area of the suction openings (without weakening the cylinder wall) and more adequate sealing of the suction boxes.

Rothrock, Virgil H. Loading and unloading mechanism for debarking machines. U. S. patent 2,702,570. Filed April 1, 1954. 20 claims. Assigned to The Pacific Coast Co. [Cl. 144-242.] An apparatus, adjustable to various diameters and lengths of plywood peeler blocks, comprises electro-hydraulic means which transfer the blocks from the saw to the debarking equipment and then discharges the block.

Steck, Rudolph E. Production of friction materials. U. S. patent 2,702,770. Filed Aug. 14, 1951. 11 claims. Assigned to Raybestos-Manhattan, Inc. [Cl. 154-81.] Material suitable for use as clutch facings and/or brake linings comprises an open-mesh cellulose fiber cloth interspersed with sheet asbestos fibers and coated with a cement.

### March 1, 1955

Arneson, Edwin L. Paperboard carton. U. S. patent 2,703,-198. Filed Sept. 13, 1950. 4 claims. Assigned to Morris

Paper Mills. [Cl. 229-41.] A florist box may be automatically set up from a cardboard blank so arranged that the container has a strutted "crash fold" bottom.

Boehm, Robert M., and Hunt, Harold R. Process of making lignocellulose hardboard. U. S. patent 2,703,293. Filed Nov. 5, 1949. 4 claims. Assigned to Masonite Corp. [Cl. 117-65.] The process claimed comprises impregnating a fibrous lignocellulose hardboard with lignin dissolved in an organic solvent, evaporating the solvent from the board and impregnating it with a siccative material (a mixture of a vegetable oil and partially polymerized petroleum hydrocarbon containing conjugated double bonds).

Brasch, Jerome F. Carton handhole reinforcement. U. S. patent 2,703,197. Filed May 13, 1954. 5 claims. Assigned to Anheuser-Busch, Inc. [Cl. 229-37.] The object of this invention is to provide handhole reinforcements without using a separate piece of material and without eliminating the function of the (bottle) carton end cover panels from which the reinforcement is obtained.

Comstock, Alfred E. Molded pulp article stripping apparatus. U. S. patent 2,703,041. Filed Dec. 21, 1949. 11 claims. Assigned to General Package Corp. [Cl. 92-56.]

Goodwin, Carl W. Apparatus for grooving paper cups and the like. U. S. patent 2,703,042. Filed Jan. 26, 1954. 4 claims. Assigned to Constellation Cup Corp. [Cl. 93-55.1.] The apparatus claimed, adapted to be incorporated in a cup-making machine, comprises means for forming a disk-seating groove in the inner surface of paper cups.

Knox, William T., Jr., and Dole, Stephen H. Fibrous wax composition impervious to fluids. U. S. patent 2,703,292. Filed Dec. 20, 1951. 1 claim. Assigned to Esso Research and Engineering Co. [Cl. 106-270.] An improved two-component film-forming wax composition for coating paperboard (milk cartons) is claimed, consisting of scale wax containing from about 1 to 4% oil and about 10% microcrystalline wax with a melting point between 145 and 180°F.

Lyall, John D. Automatic feeder for wood grinders. U. S. patent 2,703,206. Filed March 2, 1951. 5 claims. Assigned to Armstrong Cork Co. [Cl. 241-34.] The feeder claimed controls the action of the grinder ram in both its grinder pressure applying motion and its retracting motion. It will also automatically control the charging of the grinder pocket with bolts of wood to be ground.

Novick, Abraham, and Sauerman, Ernst C. Envelope patching apparatus. U. S. patent 2,703,043. Filed Nov. 3, 1950. 11 claims. Assigned to F. L. Smithe Machine Co. Inc. [Cl. 93-61.] The mechanism, particularly adapted to apply transparent window patches to open-end envelopes, is so designed, constructed, and arranged that it may be readily assembled upon or connected to existing envelope machines.

Peters, Leo. Soft plastic food package. U. S. patent 2,703,287. Filed June 10, 1950. 2 claims. [Cl. 99-171.] This invention relates to a rigidly backed suspension pack of decoratively shaped transparent film pockets for holding, molding, and displaying butter, gelatin, and the like.

Schilling, Hugh K. Carton closing apparatus. U. S. patent 2,702,973. Filed May 21, 1951. 9 claims. Assigned to General Package Corp. [Cl. 53-42.] The mechanism comprises means of carrying filled, molded pulp (egg) cartons on a conveyor and closing and sealing them. Provision is made for applying a date or code marking to the outside of the cartons as they move along the conveyor.

Waddey, Walter E., Phelan, James M., and Rogers, Dilworth T. Stabilized sulfur-containing additives for lubricants. U. S. patent 2,703,318. Filed Dec. 16, 1950. 18 claims. Assigned to Esso Research and Engineering Co. [Cl. 260-97.5.] A sulphurized member, selected from the group consisting of animal and vegetable oils, fats, resins, and the acid ester, and their hydrogenated and lower alkyl derivatives, is stabilized by cooking (after sulphurization) with 0.02-1 part by weight based on the unsulphurized material, of an active olefinic hydrocarbon at 60-400°F. for one quarter to twenty hours. The sulphurized product may be used in synthetic lubricants as well as mineral-base lubricants.

Weiss, Arthur J. Container carrier. U. S. patent 2,703,189. Filed Nov. 2, 1946. 9 claims. Assigned to Robert Gair Co., Inc. [Cl. 220-114.] A multicompartment bottle carrier.

### March 8, 1955

Cowles, Edwin. Apparatus for treating paper stock. U. S. patent 2,703,533. Filed April 3, 1952. 12 claims. Assigned to The Cowles Co. [Cl. 92-26.] The operating unit of the pulper includes a shaft bearing housing and hydraulic cylinders mounted on the flat side wall of the tank with the bedplate and knives freely exposed to the contents of the tank.

Evans, Raymond L., and Staege, Stephen A. Paper machinery. U. S. patent 2,703,683. Filed June 1, 1953. 19 claims. Assigned to The Black-Clawson Co. [Cl. 242-65.] A uniform speed reel is claimed in which the major part of the winding operation is carried out while the roll is supported on secondary ways, with the pressure between the roll and the drum controlled by fluid pressure cylinders.

Jacobs, Robert J. Paper machinery. U. S. patent 2,703,681. Filed April 20, 1951. 8 claims. Assigned to The Black-Clawson Co. [Cl. 242-58.] The invention, adaptable to hold small paper rolls, comprises a semiautomatic roll paper changer in which the driving drum is mounted within a reel for supporting the successive reels for unwinding.

McCormack, Foster D. Apparatus for making fiberboards. U. S. patent 2,703,513. Filed April 2, 1952. 5 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 92-43.] A pair of perforated cylinders, geared together for simultaneous rotation, is partially submerged in a fibrous pulp stock and between which the pulp stock, adhering to the cylinder peripheries, is adapted to be fed, and compressed into a sheet composition.

Myers, Robert E. Process of treating waxed paper. U. S. patent 2,703,754. Filed July 27, 1949. 4 claims. [Cl. 92-1.6.] Waxed paper chips, unprinted or color-printed are immersed in a chlorinated aliphatic hydrocarbon selected from the group consisting of carbon tetrachloride, ethylene dichloride, trichloroethylene, perchlorethylene, tetrachlorethane, and pentachlorethane at 121°C. The resulting wax solution is cooked to precipitate a preponderant proportion of the wax.

Scrimshaw, George W. Box, package, and wrapper. U. S. patent 2,703,645. Filed April 1, 1948. 9 claims. [Cl. 206-65.] A single, corrugated kraft board blank, incorporating overlapping and channel-forming panels and flaps, may be assembled into a a wrapper and pallet for handling shipping containers as one unit.

Thiem, Eugene T. Cone cup machine. U. S. patent 2,703,514. Filed Dec. 10, 1949. 13 claims. Assigned to Continental Can Co., Inc. [Cl. 93-36.2.] Cone-shaped paper or plastic cups (with a safety fold at the apex and a spin-rolled rim at the upper edge of each cup) are formed, reinforced, rimmed, and discharged by the machine claimed.

### March 15, 1955

Baum, Arthur A. Fluorescent whitening agents. U. S. patent 2,704,286. Filed May 7, 1954. 8 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 260-304.] The preparation of a series of ortho-aminoazo dyes is given using primuline or primuline base and an amino-naphthalene-sulphonic acid as starting materials. The bluish-green fluorescent compounds are useful as whitening agents for textiles and paper and compare favorably with those commercially available.

Brown, Paul. Packaging material. U. S. patent 2,704,268. Filed Nov. 3, 1951. 2 claims. Assigned to Packaging Materials Corp. [Cl. 154-55.] Paperboard, equally suitable for use in manufacturing double-faced corrugated heavy duty shipping and packing cases or single-faced light weight boxes, is produced in corrugated form directly from the kraft pulp.

Dyment, Harold. Sheet paper and paper board laminating machine. U. S. patent 2,704,107. Filed Sept. 12, 1951. 14 claims. [Cl. 154-35.] The machine claimed, suitable for use in printed and/or lithographic laminated display signs, comprises a feed mechanism and coacting feed-disk and feed-roller assemblies.

Doyle, James F., and Onasch, Paul L. Method of making laminated material. U. S. patent 2,704,106. Filed Dec. 30, 1950. 3 claims. Assigned to Arkell Safety Bag Co. [Cl. 154-33.05.] Crinkled heavy duty kraft paper bags are made by a method comprising feeding two paper webs, coating them with 50–67% asphalt and 33–50% reclaimed rubber composition heated to 250–350°F. The web is then passed through a presoaking composite bath at 180–210°F. prior to crinkling operations.

Goebel, Henry R., and Karr, George R. Display carton. U. S. patent 2,704,180. Filed Jan. 16, 1952. 4 claims. Assigned to Container Corp. of America. [Cl. 229-36.] A cellophane-windowed, ventilated carton for displaying glazed doughnuts may be set from a one-piece, serrated cardboard blank.

Halahan, John, Lyon, Floyd A., and Aronson, Theodore F. Paper feeding mechanism. U. S. patent 2,704,209. Filed Jan. 29, 1951. 11 claims. [Cl. 271-32.] The machine claimed, comprising a stationary vacuum type takeoff, is adapted to remove tissue-thin as well as heavier weight paper sheets from the bottom of a vertical stack.

Henderson, Wayne L., and Haymaker, Jack E. Enclosing case. U. S. patent 2,704,181. Filed Feb. 16, 1953. 3 claims. Assigned to General Electric Co. [Cl. 229-37.] A single cardboard blank may be assembled into a case for enclosing an oval capacitor.

Martin, Homer V. Expanding filing device. U. S. patent 2,704,184. Filed Nov. 9, 1950. 2 claims. [Cl. 229-68.]

Sandler, Leonard M. Cigarette package having a tearing tape. U. S. patent 2,704,182. Filed Aug. 5, 1953. 6 claims. Assigned 50% to Manus Schoenfeld. [Cl. 229-51.]

Stern, Walter. Flexible container. U. S. patent 2,704,183.

Filed Dec. 9, 1949. 1 claim. Assigned to The Cromwell Paper Co. [Cl. 229-53.] A supplemental gusset adhesively joined to the main gusset of a paper mattress bag, enables the entrance and and main body openings of the bag to be opened up to accommodate the insertion of the mattress.

Tomarin, Harry A. Carton carrier. U. S. patent 2,704,222. Filed Feb. 5, 1951. 13 claims. Assigned to Loroco Industries Inc. [Cl. 294-87.2.] Gable-topped rectangular milk containers are held in side-by-side relationship.

Wilcox, Isaac L. Carton end closure. U. S. patent 2,704,179. Filed Oct. 13, 1949. 2 claims. Assigned to Oswego Falls Corp. [Cl. 229-5.5.] An end closure structure for liquidtight rectangular cartons embodies a novel arrangement of the excess material in the corner portions of the end closure flange.

**March 22, 1955**

Andre, Eugene F., and Metzler, Charles L. Machines for applying closures to paper containers. U. S. patent 2,704,629. Filed June 24, 1952. 4 claims. Assigned to Dixie Cup Co. [Cl. 226-92.]

Copeman, Lloyd G., and Spalding, Dexter B. Wrapping material and method of making. U. S. patent 2,704,732. Filed Feb. 23, 1952. 2 claims. Assigned to Copeman Laboratories Co. [Cl. 117-155.] A self-sealing moldproof preservative wrapper has an impervious layer on one side of the sheet and on the other, an exposed fungicidal-latex coating.

Greenberg, Norman, and Greenberg, Walter S. Process for making hard, abrasion-resistant paperboard. U. S. patent 2,704,736. Filed April 16, 1951. 4 claims. Assigned to Kiddy Case Mfg. Co., Inc. [Cl. 154-138.] A cardboard sheet (free of acids) is subjected to the steps of saturation in an aqueous acetic acid solution to attain acid distribution throughout the sheet, drying, and saturation in an aqueous urea resin solution (dimethyl urea and urea) to react with the acid in the sheet, a second drying operation and finally, pressing the sheet at 300°F. The finished article, flame resistant and of high dielectric strength is suitable for use as insulating material or as containers to house electrical components.

Haldemann, Bruce M. Machine having orbitally moving dies for performing contact operations on moving sheet material. U. S. patent 2,704,577. Filed Feb. 9, 1952. 3 claims. Assigned to Manhasset Machine Corp. [Cl. 164-99.] The punch press machine claimed insures tear-free or buckle-free operations as the sheet members are caused to rotate in orbital paths and about their own axes.

Hoppe, William. Conveyor and transfer mechanism for wrapping machines. U. S. patent 2,704,592. Filed May 19, 1951. 7 claims. Assigned to National Bread Wrapping Machine Co. [Cl. 198-24.] The mechanism, for conveying articles to, through, and from a wrapping machine, comprises means to permit adjustment or substitution of the wrapping instrumentalities to meet a wide range of article sizes without changing the delivery speed or conveyor element timing.

Randall, Walter H. Molded pulp articles and process of manufacture. U. S. patent 2,704,493. Filed June 27, 1949. 5 claims. Assigned to Keyes Fibre Co. [Cl. 92-54.] The process claimed, comprises suction molding slurry pulp fibers into a hinged and pocketed egg container.

Rockstrom, Leonard, and Winship, Edward J. Printer slotter blank feed. U. S. patent 2,704,208. Filed March 25, 1952. 13 claims. Assigned to F. X. Hooper Co., Inc. [Cl. 271-10.] This invention provides means to raise the blank rear edge support bar so that when hand feeding, or at any other desired time, the corrugated board blanks are kept in engagement with the machine feed.

Stieve, Paul H. Carton with pull-out handle. U. S. patent 2,704,617. Filed Sept. 22, 1952. 1 claim. Assigned to Consolidated Paper Co. [Cl. 220-105.]

Tuttle, John N., and Cooper, Paul J. Paper dispensing sheet construction. U. S. patent 2,704,599. Filed Oct. 28, 1953. 1 claim. Assigned to Rhinelander Paper Co. [Cl. 206-57.] Waxed or glassine paper sheets have slotted perforations at their margins for retaining a pack of the sheets on a spindle in a dispenser.

Vogt, Clarence W. Wrappers. U. S. patent 2,705,104. Filed Oct. 28, 1948. 1 claim. [Cl. 229-87.] Reactivable adhesive areas provide sealing means for a pleated paper wrapper for butter, margarine, or gelatin desserts.

**March 29, 1955**

Carlile, John W. Container. U. S. patent 2,705,103. Filed Nov. 16, 1951. 5 claims. Assigned to Continental Can Co., Inc. [Cl. 229-62.] A flexible, gusseted pliofilm container is claimed for storing, handling, and shipping liquids or granular solids.

Gross, Frank C., and Luczek, Walter. Carton collapsing machine. U. S. patent 2,704,966. Filed April 27, 1954. 8 claims. Assigned to Package Machinery Co. [Cl. 93-49.] Setup cellular cardboard bottle cartons are fed to the collapsing machine directly from a forming machine.

Leonard, Carl E. Debarking machine having angularly related guide roller and feed wheel. U. S. patent 2,705,033. Filed March 19, 1954. 14 claims. [Cl. 144-208.]

Maas, Fred L. Paper novelties. U. S. patent 2,704,904. Filed March 20, 1952. 3 claims. Assigned to Paper Novelty Manufacturing Co. [Cl. 41-11.] A greeting card is fashioned from a die-cut cardboard sheet and an attached tissue paper honeycombed base structure.

# LETTERS TO THE EDITOR

## *Pulp and Paper Mill Management and Its Engineering Department*

To the Editor, *Tappi:*

An address in January by President Sebald of Armco Steel Co. before the National Industrial Conference Board on the subject of "Human Relations in Industry" emphasizes the point that, next to self interest, i.e., good pay and working conditions, comes "participation," in keeping a labor family happy and efficient.

It is in the matter of "participation" that too many pulp and paper mill managements are weak in their relations with their engineering departments. This is especially true where top management has moved up from sales, accounting, research, or even chemistry, or has moved in from some financial house. In Canada and the newer southern mills, where management has been advanced from engineering, these remarks do not greatly apply.

The group of managers first cited have little or no conception of the time, thought, and care necessary to put through a high class process change or construction project. Months, even years, may be used by management to think over and consider a forward step without discussing the matter with the chief engineer, though the latter frequently has "grapevine" knowledge of project but is kept too busy on current projects with a limited force to follow the scent.

When management's mind is practically settled on a course, then the engineering department is called in and practically told, that, in so many months, a large addition must be finished, a new plant constructed, or a major process change must be ready.

The chief engineer is told that XYZ Consulting Engineers have put through a parallel project in a brief time, that LMN. can furnish major equipment in time, and that this time schedule should be possible for the company's own engineers. Management has not absorbed the fact that pulp and paper mill work is only one of a half dozen engineering lines that XYZ is working on and that design is only one step in each of XYZ's ramifications. Such, many times, embraces promotion, financing, purchase, and construction as well as design the latter with least financial gain therein. Certainly, high class men are at the top of XYZ but their knowledge of papermaking may be slight; their head of the paper mill division may be a subordinate and frequently not the highest ability, and he is pushed to sell services with only a sketchy knowledge of the plant to be revised or the process to be altered. What LMN. offers was no doubt good some years ago, but the company may have lived on its reputation and sales ability, and its material and application can be bettered by another make.

Such a course does not develop the best sort of project nor give engineering a sense of "participation." A great deal of

preliminary thinking is required by engineering with many setups made and rejected. Much of this can be done while management is considering its part of the problem, if its engineering department is given early "participation."

A second weakness in the link between management and engineering, especially where there are numerous plants, is the failure of visiting officials from central office to advise engineering promptly of agreed upon or seriously discussed changes in construction or production contemplated by local management.

Plant management's ideas are frequently not in harmony with sound engineering, due perhaps to a limited scope in the knowledge of the local engineers, or even due to personal advantages of a locally advised project. Instances occur where local management wants an expensive change, while central engineering knows that with better maintenance and minor additions to present facilities, the same results can be obtained at a small fraction of the cost of the "new toy." A high official visits the plant, the matter is briefly discussed, and the high official says: "Probably you should have it. . . ." Local management thinks he is assured of his "toy" and to cement the matter so treats his old equipment that before word of the top official's talk gets to central engineering, the changes that could have been proposed by that department have been made impossible.

To remedy this, visiting central officials to remote plants should, on return, in a one-page memo, promptly advise engineering as well as other departments of the matters discussed.

The third improvable step in management-engineering relationship, is the matter of detailed construction and operating costs. Few managements will admit that their accounting is not adequate. Over-all production costs, property ownership, taxes, insurance, depreciation, etc., are covered, but breakdown into details needed by engineering is usually lamentably lacking for three good reasons: (1) the amount of reports and statistics required of the comptroller's office by management and government leave no time for engineering details, (2) the lack of understanding of process and construction by accountants with no chemical and engineering training, and (3) the unwillingness of local managements to have their weaknesses made public.

The first can be partly corrected by adding to general accounting and cost staff, an engineering accountant whose *first* work is to provide engineering with cost information needed to form intelligent judgments. These figures need not balance closely with usual general accounts.

As detail cost engineering is primarily required by engineering, an engineering accountant had best be attached to that department. His books or cards would be a breakdown of general accounts, giving the information needed as to strength and weakness of the project, so as to better the next one. Estimating could be part of his work. Of course, all of this would be carried out in full cooperation with local management.

Part of the setup would be, at the initiation of a project, an authorization sheet which would state expected first cost, time required, operating cost, and gain expected. At end of a year or other suitable period, a statement would go to management giving the performance of the project.

Reason (3) is a harder problem to correct in that it would require the regular inspection or audit of local costs and process operation by an engineering accountant, along with the general auditor from central office.

Such would preclude: the furnishing of process or power coal to the dwelling of a local boss, a mark-up on pulpwood received, the surprisingly high cost of a bleach plant built at same time the manager's garage was being built. It would keep local construction projects as mentioned later within bounds. It would show: that recently purchased construction machinery could be rented to advantage, that maintenance shops were doing too much manufacturing, and similar errors.

One more point toward better participation is a clear definition of boundaries of central engineering and local plant engineering.

Basically, the former should be superior in construction and processes knowledge of all kinds: the latter superior in operation and maintenance. Under these conditions central engineering should primarily handle all new construction and new process work and compare detail performances of the several plants.

But we are dealing with human beings and their needs and desires. Central engineering needs to know details of benefits and faults of its designs; local engineering needs to be acquainted with construction tactics. It is only human to wish to build "something new" to maintain morale. Therefore, a certain amount of construction, quite limited, should be handled locally. Unless carefully restrained, this can get out of bounds to the detriment of maintenance. Just where the line can be drawn it is difficult to state. A maximum sum for local construction projects can be made a target, but best results can be obtained by insistence on the part of management that *all* projects that are new be openly discussed between plant and engineering at the initiation of project, and performers agreed upon.

The consideration of engineering by management along lines discussed will result in financial economics, but more valuable, it will improve morale. This is especially important at this time with the inadequacy of comprehension of basic mathematics and the lack of analytical thinking by undergraduates, coupled with the need of 40,000 engineering graduates by industry where only 20,000 will be available next June.

George R. Wadleigh,
*Hastings on Hudson, N. Y.*

# EMPLOYMENT SERVICE

### Positions Wanted

E308-55. Technical and Research Executive, B.S., M.S. and 2 years on Ph.D. at paper school, 17 years' experience as chief chemist, executive chemist, research specialist, in control and development work on a wide variety of paper, board, and fibrous products, insulating and deadening materials, asphalts, adhesives, etc., primarily for the automotive industry, seeks new opening where his knowledge, broad background, and abilities will be of value. Has cut costs, developed new processes, won customer approvals. Patents. Successful supervisor; works harmoniously with all.

E309-55. Paper Chemist, B.S. in Chemical Engineering: background in manufacture of fine papers, filter papers, and specialties; experienced in product development, quality control, etc. Desire technical or supervisory position in the Northeast.

E310-55. Chemist, B.S. in Ch.E.; Age 27. Three years' experience in development and quality control with non-integrated specialty manufacturer. Desire similar position with future. Will consider technical service.

E311-55. Chemist. 40 years old, married, 2 children. $14\frac{1}{2}$ years' experience in the paper industry. 5 years' experience in rag papers, vulcanized fiber and plastic laminator; 8 years' experience in wood pulp, fine writing and specialty mill; and $1\frac{1}{2}$ years' in a hygrade board mill, covering supervisory, research, control and production.

### Positions Open

P444-55. Coating Chemist. Excellent opportunity for graduate chemist or chemical engineer with experience in clay coating of enamel and machine coated printing papers. Must be capable of organizing plant scale development work. Location—Midwest.

P451-55. Chemist. Some knowledge of boxboard and paper and the application of ink in a printing plant located within 59 miles of New York City. Apply in writing stating experience, education, and salary desired. National Biscuit Company, Advertising Department, 449 W. 14th Street, New York, N. Y.

P455-55. Project Engineer with creative aptitudes for paper machinery development in New England area. Applicant must have several years of Development Engineering experience and be able to readily apply fundamental laws of fluid dynamics and applied mechanics to creative work. He must be able to think in terms of and perform simple experiments for verifying ideas. He will be expected to make design layouts and specifications for subsequent detailing and manufacture. High-speed paper machine design or operating experience is desired, but not essential. Applicants to enclose photograph with complete résumé of educational and industrial backgrounds, including present salary and salary expected. All applications will be held in strict confidence.

P458-55. Chemist or chemical engineer for research and development work in sulphite and semichemical pulping, pulp processing, and by-product utilization. Laboratory or pilot plant pulping and testing experience necessary. Northern Wisconsin location. Please give personal history, résumé of experience and training, and indication of salary requirements in reply.

## TECHNICAL SALES ENGINEER

Graduate of university specializing in paper to be Assistant to Director of Industrial Sales. Must have had experience on technical or industrial papers made on either fourdrinier or cylinder machines. Previous sales experience not important. State fully practical experience. Salary $7,000 to $10,000 plus bonus. Reply P460-55.

P462-55. Graduate in Pulp & Paper Technology, Chemical Engineering or Chemistry under 35 years of age for Technical Service or Products Research work with major cellulose producer. Qualifications must include technical or production experience in paper industry. Location Memphis, Tennessee. Send complete information on education, experience and salary desired.

P463-55. Chemical Engineer—Excellent opportunity for chemical engineer to supervise all phases of technical control and development work in seventy-ton board mill. Must be a man with two to five years' experience in the board industry with ability and initiative to carry out mill projects. Work would also include certain phases of production and mill engineering. Midwest location. Send complete résumé of experience, education, and salary requirements. Good opportunity for advancement into production.

P464-55. Mechanical Engineer—Wanted to carry out expansion and rebuilding projects for multi-plant operations. Must have three to five years' experience in the paper industry. Work would include construction planning and supervision of mill maintenance programs. Midwest location. Send complete résumé of experience, education, and state salary requirements.

P465-55. Technical Director for development work and control of Testing Staff. Medium size. Fine Paper Mill in Wisconsin. Chemistry degree and five to ten years' experience. Excellent opportunity. Send résumé.

P466-55. Chemist or Chemical Engineer. Leading and rapidly expanding manufacturer of chemical cellulose has openings in technical department for chemists and chemical engineers. Should be under 35. Experience in pulp and paper field helpful but not a necessary requirement. Salary commensurate with qualifications. Inquiries confidential. Please submit details to Personnel Manager, Rayonier Incorporated, P. O. Box 207, Jessup, Ga.

## ASSISTANT TO TECHNICAL DIRECTOR

A rapidly expanding mill has a challenging position for a graduate chemist or chemical engineer under 35. The man must have the ability to supervise technicians, to do mill trouble shooting, and to do imaginative development work. Salary open. Please forward complete résumé of personal history, education, and experience, with introductory letter to P467-55, *Tappi*, 155 East 44th St; New York 17, N. Y.

P468-55. Paper Chemist. Graduate in Chemistry or Chemical Engineering will find excellent opportunity in expanding development program of solid, energetic organization in Northern New Jersey. Should be 25 to 35 years of age and have five to ten years' experience in the felt, paper, impregnated paper and allied industry field. Excellent employee benefits, plus convenient location in research and development center of the country. Write with full particulars regarding personal data, education, experience and salary desired.

P469-55. Chemical Engineer or Chemist to head research and development section conducting work on fiber preparation, utilization, and additives for Southern insulating board mill. Excellent opportunity. Send short résumé. All replies will be kept confidential.

P470-55. Organic or cellulose chemist for project leader in pulp research. Permanent position with liberal employee benefits. Replies will be confidential.

MISCELLANEOUS

A11-55. For sale three coal pulverizers. These three Babcock and Wilcox type E-56, Class 111-BA coal pulverizers were bought new, have never been used, and are in good condition. They are complete with their primary air fans, motors, controllers, and other auxiliary apparatus. For detailed information write Purchasing Department, P.O. Box 570, Savannah, Ga.

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**Sixth Testing Conference**
**of the**
**Technical Association of the**
**Pulp and Paper Industry**

**Hotel Sheraton Kimball, Springfield, Mass.**
**Sept. 28–30, 1955**

# C. J. WEST AWARD PAPERS

*Lake States Section, Appleton, Wis., April 12, 1955*

## A Device to Measure Surface Profiles or Slice Opening and Its Application to Basis Weight Problems

WILLIAM H. CUFFEY

In a study of the basis weight distribution in the cross machine direction it became apparent that information was desirable about the relative slice opening across the deckle. It was also desirable to obtain slice lip profiles in order to determine which lip caused a nonuniformity in the slice opening. Information about fourdrinier wire flatness was of interest on new and used wires on the paper machine. It was hoped that some of this information could be obtained under normal operating conditions accurately, reproducibly, easily, and quickly on the machine. In order to satisfy these requirements the device described herein was built.

### DESIGN

The device, called a Flatometer, consists of two main parts. First, some provision must be made to establish a known smooth reference path or line to which the profiles can be compared. It is desirable that this path be sturdy and permanent. Secondly, a sensing element is required to ride the surface. Some means of calibration of the entire system is required.

The reference line is provided by a heavy beam 15 ft. long and 1 ft. high. Figure 1 shows a drawing of the entire system. The beam is shown with a machined track attached. The electric motor behind the beam drives the pulley. A wire, wrapping both pulleys, draws the carriage at a uniform velocity along the track. The carriage carries the sensing element. The necessary electrical switching is provided to drive the carriage in either direction. The entire system is shown in Fig. 2.

The sensing e'ement, of course, must ride the unknown surface and provide a signal which is related to the profile of the surface. The sensing element must move across the surface in the path provided by the beam. The heart of the sensing element in a Schaevitz linear differential transformer. Briefly, it is a transformer with twin secondaries which can be electrically connected 180° out of phase. The coupling from the primary to the twin secondaries is dependent on the location of the core inside the transformer. If the core is at the "null" position where the coupling is equal to both secondaries, the net signal from the secondaries is zero. If, however, the core is moved off this "null" point, the coupling to the secondaries is no longer equal. A signal then results which is linearly related to the core's position relative to the transformer. Thus we now need merely to require the core to follow the unknown profile mechanically. The mechanical system, of course, will vary depending on the nature of the surface, how accessible it is, etc.

In Figs. 3 and 4 the sensing element is shown as it is used to measure a relative slice opening under normal operating

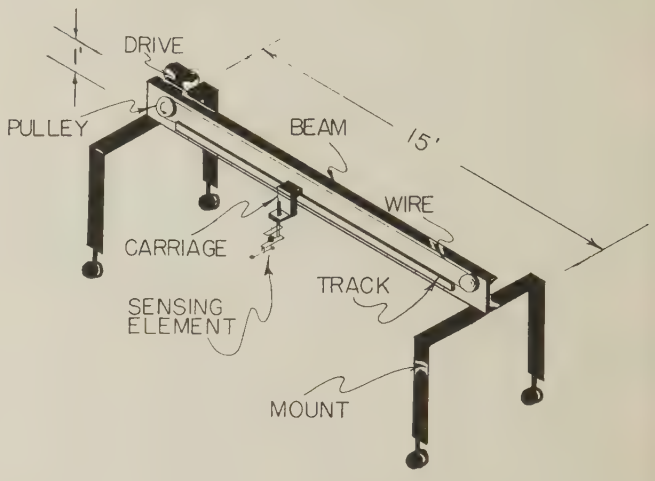


*Fig. 1. The flatometer*

conditions. The Schaevitz core follows the profile of the top lip. In addition, the transformer itself is allowed to move vertically in a manner determined by the path of another feeler riding the lower lip. Thus, if the slice opening decreases, the core will change positive relative to the transformer. If the slice opening does not change but both slice lips pass through a maximum or a minimum, the relative motion of the transformer and core will be zero. Notice that the screw which can hold the transformer in a fixed position is released. The feelers are held firmly against the slice lips by springs on the shaft and lucite block.

In Fig. 5 the sensing element is shown as it is used to measure the profile of an upper slice lip. The motion of the core is now determined by the motion of the pivoted lever arm whose feeler rides the upper lip itself. The feeler is held firmly against the lip by a spring. Of course the motion of the core is inverted because of the lever arm and pivot.

In Fig. 5 three other feelers are shown. If the sensing element is to be used with no flow issuing from the slice, then the feeler shown on the head is used. If however,

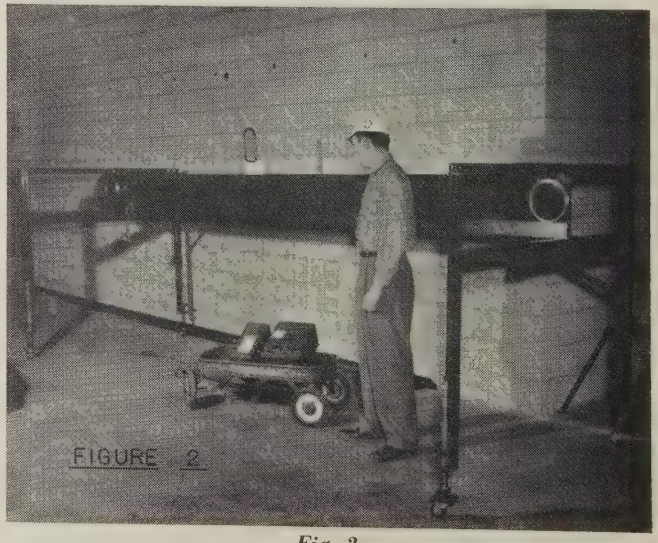


*Fig. 2*

William H. Cuffey, Physicist, Kimberly Mill, Kimberly-Clark Corp., Kimberly, Wis.

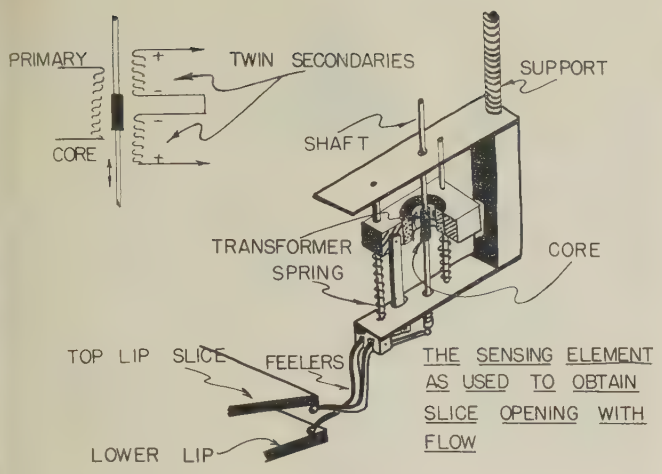


*Fig. 3*

the profile is to be determined with flow, the long right angle feelers are used. This allows the sensing element to ride up out of the flow. The transformer then stays dry, and, more important, the flow is not disturbed.

Notice in Fig. 5 that the transformer in its lucite holder is locked in place and is not free to move.

In Fig. 6 the sensing element is shown as it is used to measure the flatness of a fourdrinier wire. In this case the system must not press so hard against the wire that the surface will be altered. A brass ball is attached to a shaft which carries the core of the Schaevitz transformer. The ball rides the wire lightly. The transformer itself is held in a fixed position in a lucite holder. When the ball passes over a ridge or hill on the wire, the core is raised changing the coupling to the transformer's secondaries. This signal is fed through suitable circuitry and is plotted on a recorder.

The millimeter scale in the figure will give some idea as to approximate sizes.

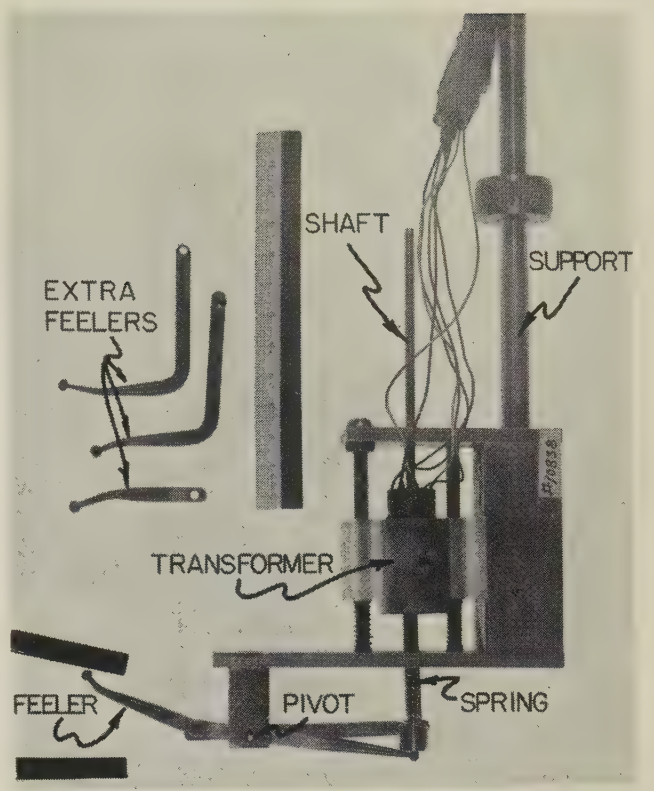


***Fig. 5. The sensing element as used to measure an upper slice lip profile***

### *Calibration*

The entire system is easily calibrated with an inside micrometer. The micrometer is mounted so it can move the feeler or brass ball through 0.005-in. steps. A plot of the chart de-

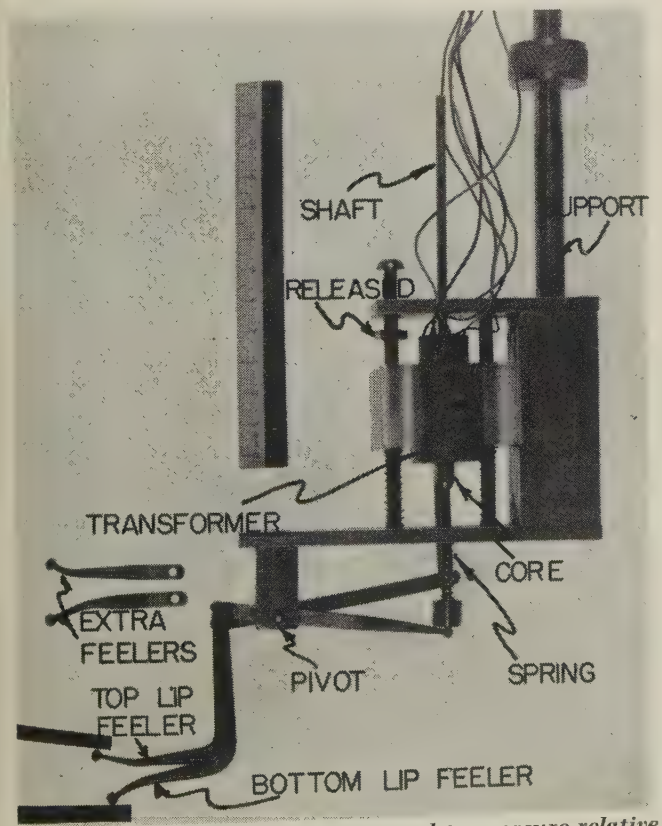


***Fig. 4. The sensing element as used to measure relative slice opening***

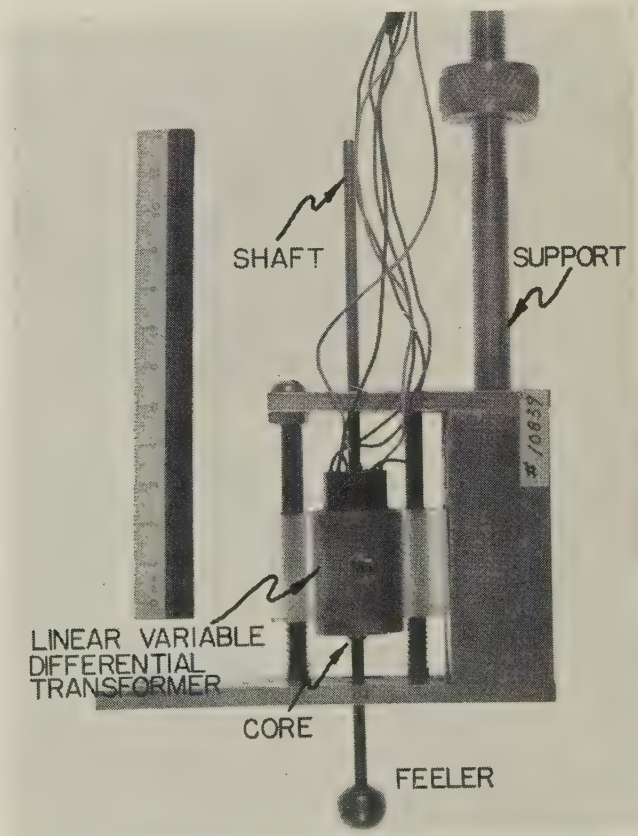


***Fig. 6. The sensing element as it is used to measure wire profiles***

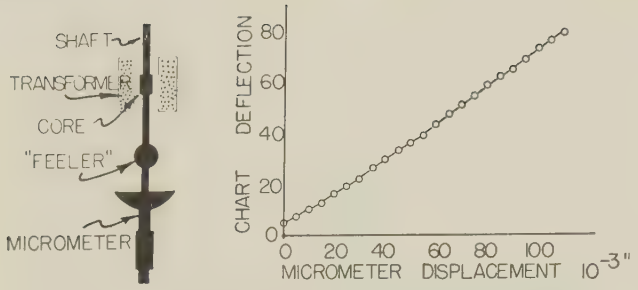


*Fig. 7*

flection on the recorder against the micrometer displacement indicates clearly that the system is linear for the displacements to be found here (see Fig. 7).

Of course, the heavy beam will sag across the span of 15 ft. In order to make certain that the track was smooth and to find the actual sag along the beam, the system was set up over a lathe bed. The sag was measured both with a dial indicator and the calibrated recorder deflection. It was found that the center dropped about 0.015 in. Since we were primarily interested in narrow monouniformities of 1 to 8 in. in width in adjacent areas, we have not bothered to correct the profiles for beam sag although it could be done.

## APPLICATION OF THE FLATOMETER TO PAPER MACHINE PROBLEMS

### *Slice Lip Profiles*

In Fig. 8 at A a top lip profile is shown as that slice lip had been set by spindle adjustment over a long period of time. Notice that the displacement for 0.011 in. is shown in several of the curves. Two curves were run to show reproducibility by winding the recorder chart back onto the parent roll.

In Fig. 8 at B a bottom lip profile is shown. The machine tender has no control over this lower lip. The difference between the curves in A and B is the relative slice opening. Notice how the top lip is generally deformed by spindle adjustment to be approximately parallel to the lower lip. Notice, too, the narrow nonuniformities in the lower lip at the extreme right. These project up into the slice opening. Both the above curves were obtained without water issuing from the slice.

### *Relative Slice Opening*

In Fig. 8 at C the slice opening is plotted across the deckle with the headbox not loaded. Notice the three narrow minima in the slice opening where there are peaks in the lower lip profile. One can also see that on occasion the top lip is carried open or closed too far to correct for nonuniformities in the lower lip. Knowing the slice opening alone is of considerable use, but to know also the profiles of the top and

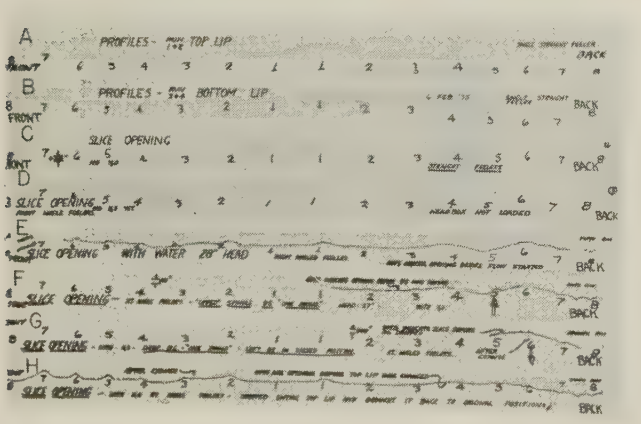


*Fig. 8*

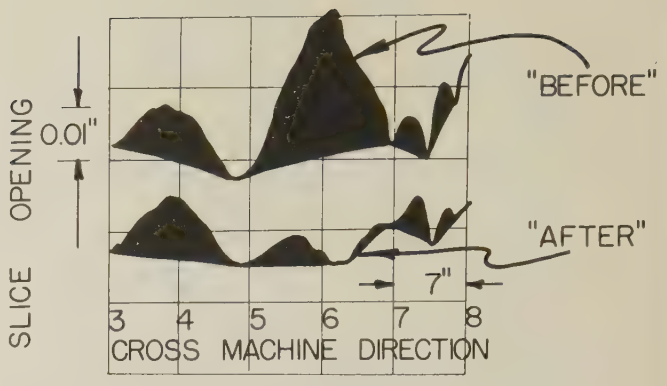


***Fig. 9. A plot of the slice opening versus the cross-machine position before and after slice adjustment***

bottom lips allows one to pinpoint the trouble if it actually is due to slice opening.

In Fig. 8 at D the feelers were moved further into the throat of the slice. When this was done, narrow nonuniformities appear at the spindle positions particularly across the left-hand side of the curve. The general shape of the slice opening curve is otherwise unchanged.

In Fig. 8 at E the relative slice opening is shown with the headbox under operating conditions. One sees that the narrow nonuniformities in slice opening are largely unchanged when the headbox is loaded. However the entire opening increases across the center more than it does at the ends giving rise to a long over-all bow.

It is of interest to know what happens to the slice opening when a single spindle is changed. In Fig. 8 at F the relative slice opening is shown in the cross machine direction after a spindle at the heavy arrow was raised. The slice opening increased at positions between adjacent spindles as well as at the changed spindle itself. Another spindle change is shown at G.

In Fig. 8 at H the slice opening is shown both before and after the top lip was dropped and then raised to a position close to the original position. In this case the slice opening across the deckle returned parallel to the original position.

In Fig. 9 the slice opening is plotted against the cross machine position before and after the slice opening was adjusted to eliminate the obvious peak. Certainly the "after" picture is to be preferred.

Just before a paper machine was shut down several hundred feet of base sheet were obtained. Cross machine direction samples were cut and run on a Foxboro beta ray sheet profiler. Nine base sheets were run simultaneously through the profiler. The basis weight distribution for another set of

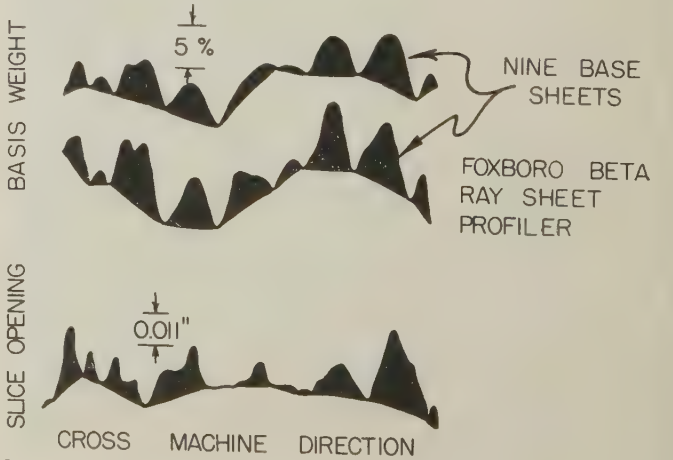


***Fig. 10. A comparison of relative slice opening to the cross-machine direction basis weight***

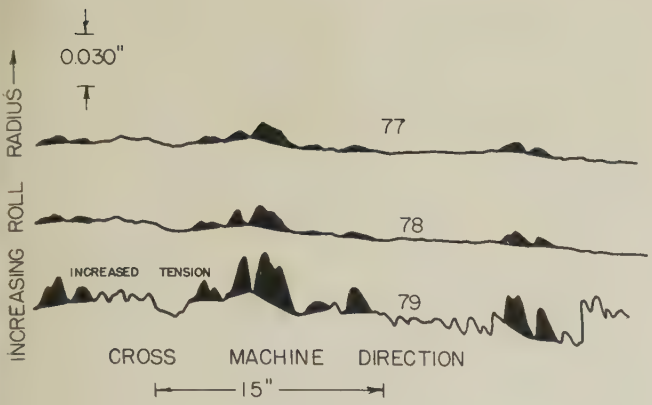


*Fig. 11. Effect of winding tension on roll profile*

nine sheets was obtained to check the variability. The curves are shown in Fig. 10. Increasing basis weight is plotted upward. The full deckle is about 11 ft.

The slice opening measured under load with the Flatometer is shown in Fig. 10. The relative slice opening is plotted against the cross machine direction. Increasing slice opening is plotted upward.

A comparison of the two distributions indicates that some of the persistent streaking in the base sheet is due to the slice opening. Knowing the slice lip profiles helps locate the source of the difficulty.

### *A Comparison of Finished Roll Profiles at Different Tensions*

In Fig. 11 the roll profile is plotted against the cross deckle position for three rolls. The rolls numbered 77 and 78 were wound at a lower tension than the roll numbered 79. It is fairly obvious that the roll wound at the higher tension has the least uniform profile.

### *Fourdrinier Wire Profiles*

If the fourdrinier wire itself does not lie flat, it will certainly influence the basis weight distribution across the machine. If the wire ridges upward and the stock on the wire has a flat top surface, a light streak will result at the ridge in the wire. In Fig. 12 profiles of a used fourdrinier wire on a machine are shown. The sensitivity is indicated as 0.016 in. between the indicated lines for the top two curves. Here the profile was repeated on the same path over the wire to show reproducibility. The sensing element in this case was moved in the cross machine direction. One sees that on this used wire there are ridges which can be as high as 0.040 in. At this time there was no stock on the wire, and the wire was not moving.

In the lower curve in Fig. 12 the sensing element of the Flatometer was stopped at about the machine center. The wire was then slowly and continuously moved. The resulting

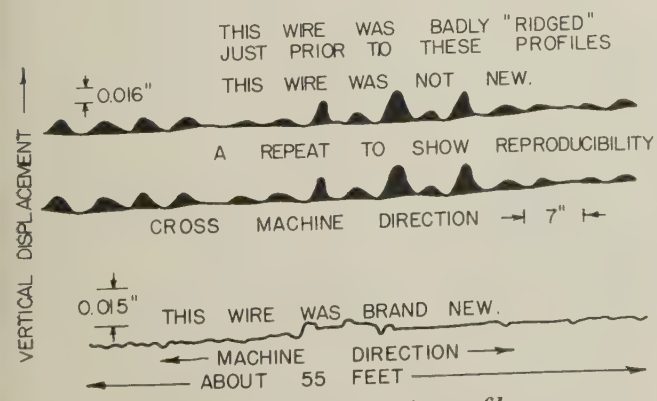


*Fig. 12. Fourdrinier wire profiles*

plot is a profile of the wire in the machine direction. In this case the wire was brand new and under normal operating tensions. Notice the sensitivity is now 0.015 in. between the indicated lines. On occasion we have seen the machine direction profile possess a periodic profile which is attributable to an out-of-round table roll lifting the wire. After the wire is worn, the machine direction profile becomes flatter. This is not the case, however, with the cross machine direction profiles.

Ira Caple cooperated in the design of the Flatometer. Much help and many valuable suggestions have been received during the course of this work from Arthur Bellinghausen, Ira Caple, Ralph Caston, Howard Comstock, Myrl N. Davis, Paul Eastwood, Robert J. Greenwalt, Harold H. Heller, Irving Kersten, Edward Reiter, and Lowell Zabel. The Kimberly mill operating and engineering departments have cooperated in this work.

The Schaevitz Linear Variable Differential Transformer is made by Schaevitz Engineering, Post Office Box 505, Camden 1, N. J. The Foxboro Sheet Profiler is made by the Foxboro Co., Foxboro, Mass.

A C. J. West Award paper presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., April 12, 1955.

# An Investigation of the Freeness and the Index of Fiber Length Tests

F. P. LODZINSKI

Stock testing can be of great value not only in keeping stock uniform, but also in eliminating some of the many faults in the final product. Before this stock testing can become of great value, the tests themselves have to be understood more fully. Consequently, an effort was made to find additional information on the stock testing tools at the Whiting Plover Paper Co. The freeness test and the index of fiber length test were the two stock testing tools investigated. A description of the index of fiber length and consistency tests appear in the appendix of this paper. The freeness test was performed according to TAPPI Standard T 227 m-50 on a Schopper-Riegler instrument.

The effect of consistency on the freeness and the index of fiber length tests, which were designed for a 0.2% consistency, was determined first. A large sample of 25% rag stock, enough for several laboratory tests, was collected after normal production refining. The consistency of this sample was determined and freeness and index of fiber length tests were taken. The index of fiber length test was accomplished by passing stock of 0.2% consistency through a grid. The fibers that stapled over the grid were weighed (oven-dry) and reported as the index of fiber length. Other freeness and index of fiber length tests were then made, but instead of using stock of 0.2% consistency, consistencies from zero to 0.2% were used. The results of this procedure were plotted in Fig. 1. From Fig. 1 freeness and index of fiber length versus consistency appear to have a fairly straight line relationship and therefore the accuracy of the freeness and index of fiber length tests depend on the accuracy of the consistency measurement. Because of the variation of stock consistency experienced at the Whiting Plover paper mill, consistencies were determined before making stock tests.

To investigate the freeness and index of fiber length tests further, the majority of long fibers was removed from a sample of stock and the effect of this removal on the freeness and index of fiber length tests was studied. These fibers were removed in the following manner: each time an index of fiber length test was made, a small portion of the fibers were removed from the sample. Therefore, by making this test of a sample, some fibers were removed by the grid and the rest remained in suspension. By repeating this procedure on the same suspension a number of times, a large portion of fibers were removed from a sample, tests made, and the results studied.

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A portion of the large sample obtained for the previous experiment was used for this experiment. The consistency of this sample was determined again and freeness and index of fiber length tests were taken. The next step was to take another portion of the original sample, run another index of fiber length test, this time carefully saving the suspension of

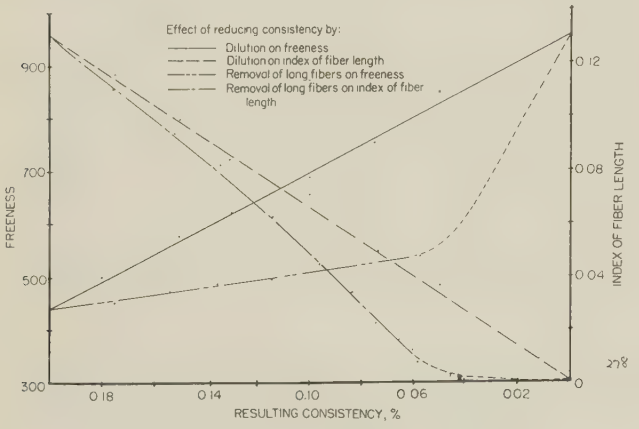


*Fig. 1*

stock that flows through the grid. The fibers remaining on the grid were weighed (oven-dry) as a check on the original index of fiber length test. The stock that remained in suspension was used for another index of fiber length test. This procedure was repeated until the stock had been poured through the grid 31 times. The remaining suspension was examined under a microscope and showed that this suspension contained mostly fines.* After this procedure was completed, consecutive pour-throughs were again made, but in this case freeness tests were run instead of index of fiber length tests. There were less data pertaining to the freeness tests of this experiment because each time a freeness test was run that portion of the sample had to be discarded. The data of this experiment were also plotted in Fig. 1.

Figure 1 showed that the pouring of the sample through the grid 31 consecutive times reduced the consistency from approximately 0.200% to approximately 0.056%. This indicated that approximately 72% of the stock, which was long fiber, was removed by the grid. The Schopper Riegler freeness of the stock suspension remaining after the 31st consecutive pour-through increased only 90 ml. over the original freeness, even though the freeness test on the suspension remaining after the 31st consecutive pour-through was made at a consistency of approximately 0.056% and the original freeness was made at a consistency of approximately 0.200%. Figure 1 also showed that a reduction of consistency from approximately 0.200% to approximately 0.056% by diluting the stock, instead of selectively removing the long fiber portion, made the freeness increase 355 ml. over the original freeness. Therefore, the freeness test in the case of 25% rag bond stock was dependent largely on the amount of fines in the sample and only slightly dependent upon the longer fiber.

The consistency of the suspension at the time of the 31st consecutive pour through was 0.056% and the index of fiber length was 0.008. Figure 1 showed that diluted stock at 0.056% consistency would have an index of fiber length of 0.038. Therefore, the index of fiber length was dependent largely upon the amount of long fibers in the sample and was not appreciably affected by the amount of fines.

The conclusion was drawn that the freeness test was primarily a test of one characteristic of the stock, namely, the amount of fines, and the index of fiber length test was primarily a test of another characteristic of the stock, namely, the amount of long fiber.

The long fibers were removed from a variety of other pulps and studied in the same manner. The choice of pulp in three such series was done in such a way as to have one of different refining, one of a different grade, and one of a different basis weight. The results of these three identical experiments are not shown, but their curves were very similar to the experiment just described.

A confirmation of the conclusion drawn from the preceding experiment was made by removing a large portion of the fines from a sample of stock and by observing the effect of this removal on the freeness and index of fiber length tests. This study was made in the following way.

A laboratory beater equipped with a washer cylinder, similar to the production size washers of a rag content mill, was used to wash out the fines. This beater was furnished with a portion of the same sample used in the preceding experiments. The consistency was determined and tests were made on the stock before the washing was commenced. The washing was then started and fresh water added continually to replace the wash-out material. Consistency, freeness, and index of fiber length tests were performed periodically throughout the washing cycle. The washing was continued for 2 hr. which was long enough to remove a majority of the fines.

The 2 hr. of washing reduced the consistency in the beater from 2.4 to 1.7% which indicated that approximately 29% of the material was washed out. A microscopic examination of the washed out material showed that this material was nearly all fines. The removal of these fines caused the freeness test, which was made each time with the regular 0.2% consistency, to rise from 445 to 790 ml. The removal of these fines also caused the index of fiber length to rise from 0.132 to 0.213. This increase of the index of fiber length was accounted for by the fact that the fines present in the sample before the washing were replaced by long fibers in the sample taken after washing.

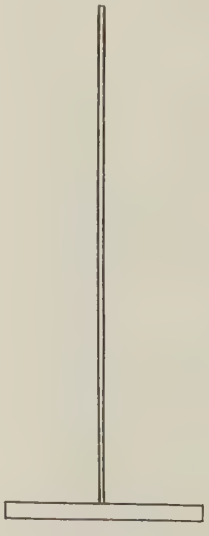


*Fig. 2*

*Fig. 3*

* The term fines when mentioned in this paper include not only fiber fines, but also a small amount of filler.

Again the conclusion was drawn that the freeness test was most strongly effected by the fines in the stock whereas the index of fiber length was primarily determined by the long fiber portion. This agreed with and confirmed the conclusions of the previous experiment in which the long fibers were removed selectively over a relatively wide consistency range.

## CONCLUSION

The knowledge obtained from the experiments described in this paper help to understand the freeness and index of fiber length tests much more fully. Consequently, stock preparation can be controlled more satisfactorily by the use of the two tests, especially when used simultaneously. The index of fiber length test predicts whether the finished product will give satisfactory operations or not in an air drier. Simultaneous use of both tests foretell to a very large extent the formation and watermarking ability of the stock. In some cases a tendency for the paper to curl can be predicted. The simultaneous use of both tests make possible a study of the refining equipment as to whether each piece of the equipment has cutting or hydration ability. The use of these tests also help in many other stock preparation problems.

In the stock preparation department, there has always been a great demand for more knowledge of the methods used in stock testing. The reason for this demand is obvious. Quality conscious customers as well as high-speed paper machines force stock preparation to be as uniform and correct as possible. Often, however, a run of paper made at one time is not the same as another even though it is intended to be so. In many of these cases the stock preparation department is at fault, even though this fault may be very hard or even impossible at times to correct. The old saying that paper is made in the beater room holds true today, although it might be more appropriate to say paper faults are made in the beater room.

## APPENDIX

### *Consistency Procedure*

The consistency of a particular sample by this method was determined in 5 min. or less. The use of a Cenco moisture balance and a hot plate were the primary factors in speeding up results. The Cenco moisture balance is a modified torsion balance with a heat lamp and a mechanism to zero out the varying weights of filter papers. The scale is conveniently divided into 100 divisions, each with 10 subdivisions. The consistency of a sample was found by placing a filter paper in the Cenco moisture balance with the heat lamp on. This lamp removed the moisture from the filter paper. After careful dilution and mixing of the sample, a convenient but definite volume of stock was placed in a graduate. This definite volume was determined by the amount of dilution and the torsion constant of the moisture balance. For all practical purposes the filter paper was moisture-free and the zeroing mechanism was adjusted so that the moisture balance scale read zero. The filter paper was then placed on a suction flask and the diluted sample of set volume poured onto it. After the water had penetrated the filter, the filter was removed with the fibers, pressed between blotters and placed on a hot plate. After 3 min. of fast drying the filter paper and stock were quickly passed to the moisture balance with the heat lamp on. Since a definite volume of stock was filtered, the moisture balance read the consistency directly. The volume of stock containing 0.2 gram of oven-dry material was determined from a chart showing the amount of stock to use for any consistency.

### *Index of Fiber Length Test Procedure*

A method of finding an index of fiber length was set up so that it would be as accurate as necessary and also that it would be accomplished as quickly as possible. Keeping in mind the fact that a 0.2% consistency would be used in this test, a grid and container illustrated in Figs. 2 and 3 were designed.

The procedure was as follows. The sample was taken, diluted for better accuracy, and the consistency determined. The correct volume determined by the chart was poured into a graduate and diluted to 1000 ml. The sample in the graduate was then mixed and poured into the metal container (Fig. 3) with the stopcock closed. The grid (Fig. 2) was then put into the container, jerking it a little as it was being lowered through the stock suspension. After the grid was all the way down, a few seconds were taken for the turbulence of the suspension to quiet. The stopcock was then opened completely and the suspension passed through the grid. The grid was then removed from the container and the fibers clinging to it washed onto a filter paper of known weight (oven-dry). The filter paper with the fibers was then dried first on a hot plate for faster drying and then in a tray suspended from the torsion balance located above the oven. If the filter paper was zeroed out originally the reading on the scale in grams can be reported as the index of fiber length.

By arranging each part of the procedures so that as little time as possible was lost, the consistency, index of fiber length, and freeness tests were accomplished in 10 min. The accuracy of such a hurried test was surprisingly good and definitely sufficient for the use intended.

Indebtedness is acknowledged to L. A. Moss, who designed the index of fiber length tester used and to W. E. Carlson who contributed the idea of confirming the conclusions with the washing out of the fines experiment.

A C. J. West Award paper presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., April 12, 1955.

# Soil Filtration Studies on Spent Sulphite Liquor

J. MARSHALL BUEHLER

As a means of reducing stream pollution, several sulphite pulp mills have turned to the lagooning of spent sulphite liquor. Under this plan, spent liquor is impounded in earthen ponds or sometimes sprayed over the surface of the ground.

The liquor stands in the open air for a short period during which time a considerable portion of the sulphur dioxide passes off. The liquor then filters through the soil. Suspended material is removed by the filtering action, and the bacteria in the soil reduce the organics. With even a partial elimination of some of the organics, sulphur dioxide, and suspended material, there will be a corresponding elimination of the biochemical oxygen demand.

Inasmuch as ground seepage cannot be easily traced and since there will be dilution with ground water, as well as the fact that the large ponds could not be easily controlled, it was decided to build a lysimeter which would serve as a pilot plant for the lagoons. In this pilot plant various changes in liquor dosage to the soil could be more easily and precisely studied. In this way it was hoped that methods could be applied to the liquor lagoons to increase the biochemical oxygen demand reduction.

## DESCRIPTION

A stainless steel cylinder (Fig. 1), 14 ft. high and 18 in. in diameter was fitted with a blind flange on one end. A strainer plate was welded to the inside about 1 ft. above the blind flanged base, and a tap and valve were attached to the column just below the strainer plate. Two flanged outlets were installed, one just above and the other just below the strainer plate. These two openings serve as clean-out ports and, during use of column, both are blind flanged.

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A rubber hose runs from the outlet tap of the liquor chamber below the strainer plate to the top of the column and then down again into a 13-gal. carboy which serves as a receiving chamber for the effluent liquor. The purpose of this hose is to maintain a saturated condition in the column as well as a pool of liquor on the top of the dirt fill.

The entire column, above the strainer plate, is filled with sandy soil which rests on various gradations of gravel, which in turn rest on the strainer plate.

A 30-gal. tank is located on a platform a few feet higher than the column. This is the supply tank for the feed liquor and is equipped with an outlet at the bottom: said outlet is connected to a valve and a constant head floating orifice feed.

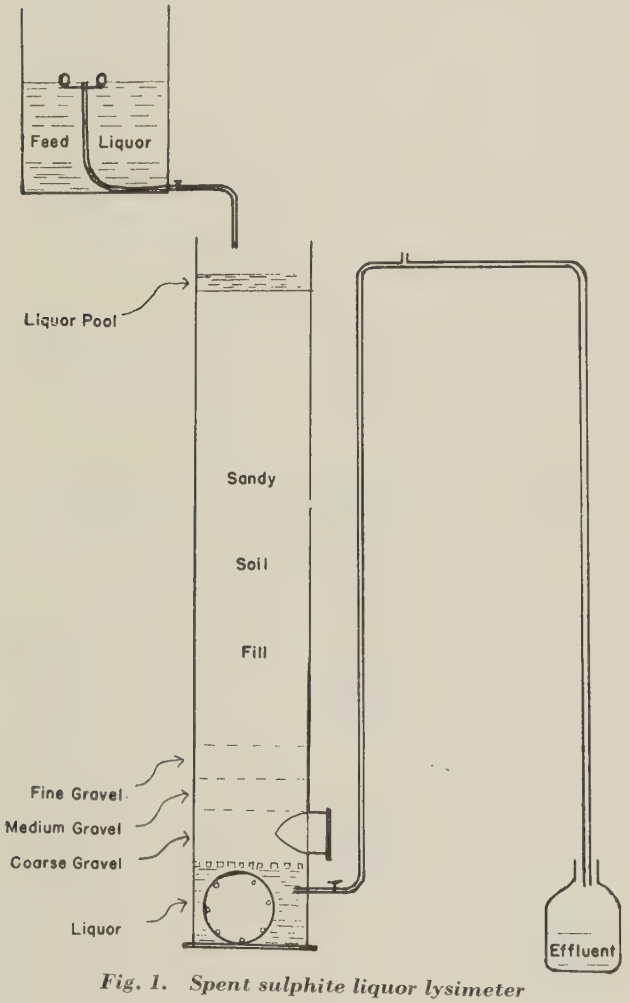



*Fig. 1. Spent sulphite liquor lysimeter*

The column, supply tank, and all fittings are of stainless steel while the effluent container is a glass carboy.

## OPERATION

In normal operation, liquor is transported from the blow pit to the supply tank in 5-gal. cans. The rate of application of this liquor to the column is regulated by a screw-type rubber tubing clamp which is attached to the rubber tube connecting supply tank outlet with column.

Liquor is sampled daily at the supply tank and at the effluent container, said samples being composited until time of analysis. The composite samples are kept in polyethylene containers which, in turn, are kept in the freezing compartment of a refrigerator until time of analysis.

## ANALYSIS

The pH value was determined on a standard pH meter while specific gravity was determined on a specific gravity balance. Biochemical oxygen demand was determined via the Winkler method. Samples were not seeded at first, but as more concentrated liquor was encountered, Wisconsin River water was added as seed to the incubator samples.

Sugars were determined by Somogyi's method as outlined by the Sulphite Pulp Manufacturers' Research League. Total solids were determined by means of a Bausch & Lomb refractometer and a conversion table. Sulphur was determined gravimetrically by barium chloride precipitation of sulphates, after first digesting all organics with concentrated perchloric, nitric, and hydrochloric acids.

**Table I. Record Operation Soil Percolation Column**

Run no._____ Date_____
Room temperature, °C._____ Time_____
Percolation rate_____ for_____ past_____ hours
Characteristics of feed SSL_____ % total solids. Wood_____
Elapsed time current run_____ hr.
Feed liquor on hand_____. Was more added today?_____

Effluent:

1. Observations (color, odor, etc., evidencing change)
2. Take sample from 24-hr. effluent collection for composite weekly tests:

B.O.D. (p.p.m.) of SSL
Feed_____
Effluent_____ % Change_____
Total sulphur, (g./l.)
Feed_____
Effluent_____ % Change_____
Total sugars, g./l.
Feed_____
Effluent_____ % Change_____
Solids, p.p.m.
Feed_____
Effluent_____ % Change_____
pH
Feed_____
Effluent_____ % Change_____
Specific gravity
Feed_____
Effluent_____ % Change_____

Analyst_____

Various observations were also made and recorded which included odor, color, and suspended solids content.

Data were reported following each analysis on printed forms and contained the results of analysis as well as column operating data (Table I).

**Run 1A**

| | |
|---|---|
| Liquor solids concentration | 2% |
| Rate of application | 6 gal./day |
| Hours of operation | 523 |
| Average B.O.D. reduction | 32% |
| Average sulphur reduction | 9% |

This run was a warm-up run. Rather than risk possible sterilization of the soil with concentrated liquor, it was decided to begin with weak liquor and gradually raise the concentration, thereby acclimating the bacteria to the liquor conditions. The dosage is the same rate as the lagooning of liquor. The B.O.D. reduction was quite favorable in this run. The per cent reductions are an average of all analyses made in that particular run.

**Run 3A**

| | |
|---|---|
| Liquor solids concentration | 2% |
| Rate of application | 12 gal./day |
| Hours of operation | 744 |
| Average B.O.D. reduction | 30% |
| Average sulphur reduction | 25% |
| Average sugar reduction | 46% |
| Average solids reduction | 18% |
| Average pH increase | pH 3.2 to pH 5.1 |

This run was made under the same conditions as run 1A

except that the rate of application was doubled. Results seem to be quite similar to those obtained in run 1A.

**Run 4A**

| | |
|---|---|
| Liquor solids concentration | 4% |
| Rate of application | 6 gal./day |
| Hours of operation | 1201 |
| Average B.O.D. reduction | 17% |
| Average sulphur reduction | 21% |
| Average sugar reduction | 49% |
| Average solids reduction | 14% |
| Average pH increase | pH 3.3 to pH 4.9 |

This run was made under the same conditions as previous runs except that the concentration of liquor solids was increased to 4%. Generally speaking, the results are quite similar to those found in run 3A except that the B.O.D. reduction was roughly only half of what it was in run 3A.

**Run 6A**

| | |
|---|---|
| Liquor solids concentration | 6% |
| Rate of application | 6 gal./day |
| Hours of operation | 2324 |
| Average B.O.D. reduction | 19% |
| Average sulphur reduction | 24% |
| Average sugar reduction | 47% |
| Average solids reduction | 15% |
| Average pH increase | pH 3.3 to pH 4.8 |

In this run, the concentration of the liquor was increased to 6% solids. The results are very similar to those found in run 4A.

**Run 9A**

| | |
|---|---|
| Liquor solids concentration | 9% |
| Rate of application | 6 gals./day |
| Hours of operation | 2229 |
| Average B.O.D. reduction | 8% |
| Average sulphur reduction | 12% |
| Average sugar reduction | 40% |
| Average solids reduction | 7% |
| Average pH increase | pH 3.3 to pH 4.7 |

This run was made on full-strength liquor as obtained from the blow pit. The pH change and the sugar reduction remained about the same, while the sulphur, B.O.D. and solids reduction, were considerably less than in previous runs.

**Run 9B**

| | |
|---|---|
| Liquor solids concentration | 9% |
| Rate of application | 6 gal./day |
| Hours of operation | 745 |
| Average B.O.D. reduction | 4% |
| Average sulphur reduction | 5% |
| Average sugar reduction | 7% |
| Average solids reduction | 0% |
| Average pH increase | pH 3.4 to pH 4.6 |

This run was similar to run 9A in that liquor was used at the same concentration as it came from the blow pit. However, nutrients for the bacteria were added. Nitrogen in the form of urea and phosphorus in the form of trisodium phosphate were added to the liquor in the proportion of 60 mg. per liter of nitrogen and 10 mg. per liter of phosphorus. It is evident from the table above that this run produced the poorest results to date.

This run was a modification of run 9A. The rate and concentration were the same; the only difference being that the pH of the liquor was raised by the addition of kraft lime sludge, to a value of 5.0 to 6.0. About 440 grams of air dry lime sludge was added to each 5-gal. can of liquor. The final pH value dropped to about 4.8 after passing through the column. This value is only slightly higher than the final pH of

**Run 9C**

| | |
|---|---|
| Liquor solids concentration | 9% |
| Rate of application | 6 gal./day |
| Hours of operation | 671 |
| Average B.O.D. reduction | 11% |
| Average sulphur reduction | 9% |
| Average sugar reduction | 21% |
| Average solids reduction | 3% |
| Average pH increase (between feed and final effluent) | pH 3.1 to pH 4.8 |

previous 9% runs in which the liquor was not brought close to neutrality before entering the column. The B.O.D. reduction was higher than run 9A or 9B. There was a considerable improvement in comparison to run 9B (nutrients).

## GENERAL OBSERVATIONS

All liquor showed a reduction in B.O.D. as it passed through the earth in the column. The reduction varied, starting out quite high when weak liquor was used and gradually dropping off as the liquor became more concentrated. The pH value was always higher on the effluent, usually rising to about the same level, regardless of which run was being carried out.

There was always a complete removal of suspended solids. The suspended material, consisting primarily of fiber, settled out in the supply tank and on the top surface of the soil in the column.

The effluent of the lysimeter was always of a darker color than the feed liquor and always had a changed odor. This odor was sometimes a fermented, sour, and foul one.

On some occasions a mold, resembling scum, formed on the liquor in the effluent carboy. During the clean-outs between runs, when the liquor chamber below the strainer plate was opened, a thick, black, slimy material was found to be coating all inside surfaces.

No odors were encountered in the area of the lysimeter; only the contents of the effluent container gave off the odor previously mentioned.

No plugging of the soil was ever encountered and all runs were made with the same original soil fill.

## CONCLUSION

The biochemical oxygen demand of spent sulphite liquor can be definitely reduced by passing the liquor through soil.

Factors contributing to this reduction are the partial removal of sugars and sulphur, as well as a complete removal of suspended solids. pH values are raised close to the neutral value.

The B.O.D. reduction becomes less as time progresses and stronger liquor is encountered. This may be due to an overloading condition or a gradual exhaustion of bacterial effect of the soil. The addition of nutrients, at this stage, are of little value, while the addition of kraft lime sludge was found to be a stimulant to greater B.O.D. reduction at this same time.

Furthermore, the soil filtration tends to distribute waste discharges by discharging them at a constant rate rather than the periodic overloading encountered with intermittent discharges.

Further work will be done to determine the possibility of seeding the liquor with bacteria as well as a combination of seed, lime, and nutrients. Further runs with fresh soil are also contemplated.

A C. J. West Award paper presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., April 12, 1955.

# Laboratory Ink Drying Time Tests with Letterpress Inks and Papers

NORMAN J. BECKMAN

THE manner in which printing inks dry on paper can be a principal factor in determining pressroom production efficiency and customer acceptance for the printer. The wet ink film applied to the paper at the moment of impression must undergo physical and chemical changes which render the printed image indelible to normal handling conditions during and subsequent to printing.

The paper manufacturer is concerned with ink drying characteristics of his paper under average field conditions from the standpoints of product design and customer reaction. Competition requires that the best possible balance be maintained between the many sheet properties important in printing consistent with cost and use requirements. Performance levels characteristic of a given paper grade must be established for analyzing customer complaints against the paper.

There exists a need for laboratory testing procedures which will give an objective measure of ink drying behavior on paper. For the present such tests must depend upon simulated use conditions until fundamental relationships are established between the complex array of paper, ink, and printing variables. With proper design such tests may serve both as a research tool and a means for commercial paper quality evaluation.

The ink drying time tests here reported are limited to letterpress halftone black inks designed for sheet fed, flat-bed cylinder press equipment, and coated book papers designed for letterpress printing. Ten regular production papers made by five different paper producers are used to demonstrate the tests. These papers are briefly described in Table I. A total of 27 different ink samples were collected from two sources: directly from shops printing the above papers and directly from three leading ink manufacturers. The collection of inks include samples from ten different ink companies. These inks, here identified only by a code number, represent regular commercial types widely circulated for use on papers of the above types. Only factory-sealed cans were used to avoid additional confusion resulting from pressroom additives. Both papers and inks were stored at 50% R.H., 72°F. throughout the study.

## THE I.G.T. DRYING TIME RECORDER

The I.G.T. drying time recorder used for the present ink drying experiments was developed by the Institute for Graphic Techniques, Amsterdam, Holland.* This instrument gives a continuous time record of ink transferred from a wet print to a standard chart surface, and will test up to ten printed specimens simultaneously. The instrument is shown in Figs. 1 and 2, and schematically in Fig. 3.

Referring to Fig. 3, cylinder D, $3^5/_8$ in. in diameter, $8^5/_8$ in. long, rotates at a constant speed through about $^2/_3$ of 1 revolution. Paper test strips cut $^3/_4$ in. wide, 11 in. long are mounted girding drum D, inked side out, secured by spring clamps C. The set-off record chart, R, $8^1/_4$ by 11 in., feeds from a slotted tube, T, under a slight tension induced by the rider bar, b, and is clamped to the rotating drum by the bar B. The recording chart is brought into contact with the printed test strips on the recorder drum by a ballpoint scanning stylus, S, having a tip diameter of 0.126 in. The stylus assembly travels continuously between the ends of cylinder, D, under a gravity loading force of 30 to 80 grams adjustable with weight, W. With the gravity loaded, pivoted

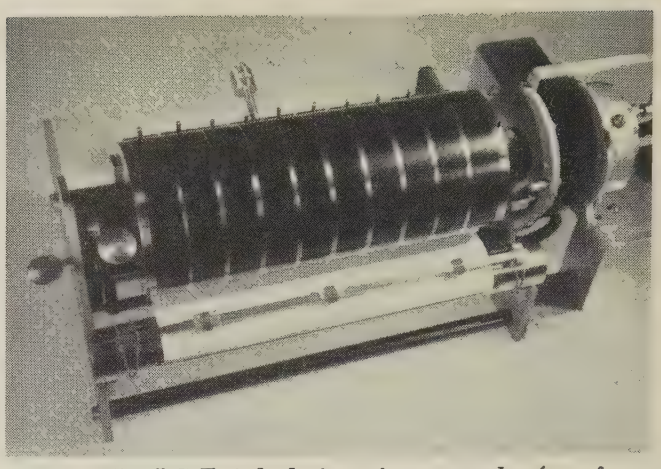


*Fig. 1. The I.G.T. ink drying time recorder (top front view)*

stylus arrangement the instrument is not very sensitive to caliper differences of the paper test strips. There is no tangential motion of the record chart relative to the paper test strips mounted to cylinder, D. The set-off chart does not touch the inked paper specimens until contact is established by the scanning stylus.

As received from the manufacturer, a single test cycle of about 40 hr. was possible. The instrument has since been modified such that full drum displacement can be varied from 4.5 to 68 hr. in five steps.

For the data here reported, clear cellulose acetate, 0.003 inch caliper, was selected as a standard chart material on the basis of uniform thickness and surface, zero ink absorbency, and uniform transparency. Drying of the ink is judged in terms of the light transmission of the ink transferred to the acetate chart under the scanning action of the stylus.

Best results have been obtained using the 80-gram loading force on the stylus. For a 0.003-in. acetate chart and coated book papers printed at films of 2.5 to 5.0 mu, a circular area of contact 0.29 ± 0.02 mm. in diameter is established between the chart and the test print on the recorder drum. This corresponds to an average pressure of about 1725 p.s.i. effecting set-off from the paper print to the acetate.

A typical record chart is shown in Fig. 4, where it becomes apparent that visual determinations of end points of set-off are subject to error. The chart is evaluated with a Bausch and Lomb Opacimeter. A hinged template of 0.0112-in. stock slides horizontally over a graduated scale mounted to the Opacimeter platen and holds the acetate set-off record for a given test strip centered over the instrument aperture. With the instrument calibrated in the standard manner, the "zero-ink" transmission of a clean piece of the acetate chart

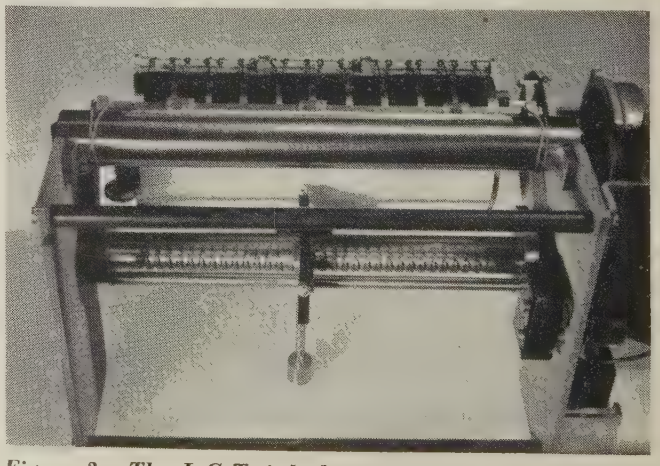


*Figure 2. The L.G.T. ink drying time recorder (bottom front view)*

NORMAN J. BECKMAN, Research and Development Center, Kimberly-Clark Corp., Neenah, Wis.

* Purchased from Rudolph Meyer's, Inc.; K. E. Saunders Agencies; 141-30 Pershing Crescent I. A.; Jamaica-Briarwood 35, Long Island, N. Y.

**Table I. Letterpress Coated Book Papers for Ink Drying Time Tests**

| *Paper sample code* | *Basis weight, lb. (25 × 38/500)* | *Cady single sheet caliper, in.* | *Gurley air porosity, sec./100 cc.* | *Ingersoll finish* | | *75° Gloss* | |
|---|---|---|---|---|---|---|---|
| | | | | *Wire* | *Felt* | *Wire* | *Felt* |
| A | 78.8 | 0.0038 | 2870 | 45.2° | 44.1° | 58 | 58 |
| B | 79.8 | 0.0041 | 3152 | 44.1 | 44.0 | 59 | 59 |
| C | 72.4 | 0.0034 | 4404 | 45.3 | 45.9 | 60 | 61 |
| D | 78.9 | 0.0035 | 5640 | 48.0 | 48.6 | 71 | 75 |
| E | 70.8 | 0.0032 | 3516 | 45.8 | 46.6 | 59 | 57 |
| F | 70.1 | 0.0034 | 5420 | 45.5 | 45.8 | 53 | 52 |
| G | 70.3 | 0.0023 | 5020 | 45.2 | 45.0 | 51 | 50 |
| H | 70.4 | 0.0034 | 5412 | 45.8 | 45.2 | 51 | 54 |
| I | 71.6 | 0.0036 | 1840 | 45.5 | 44.2 | 46 | 42 |
| J | 80.8 | 0.0043 | 1670 | 43.5 | 43.8 | 53 | 54 |

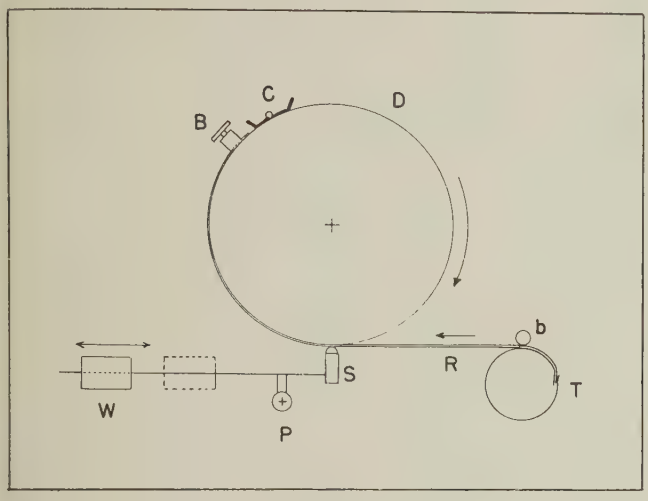



*Fig. 3. Schematic diagram of the I.G.T. drying time recorder*

is first established with the template window backed by the white standard body. (This transmission level remains constant to within ±1.2% at 91.8.)

*The end point of ink drying is then defined as the length along the chart where the optical transmission of the set-off record*

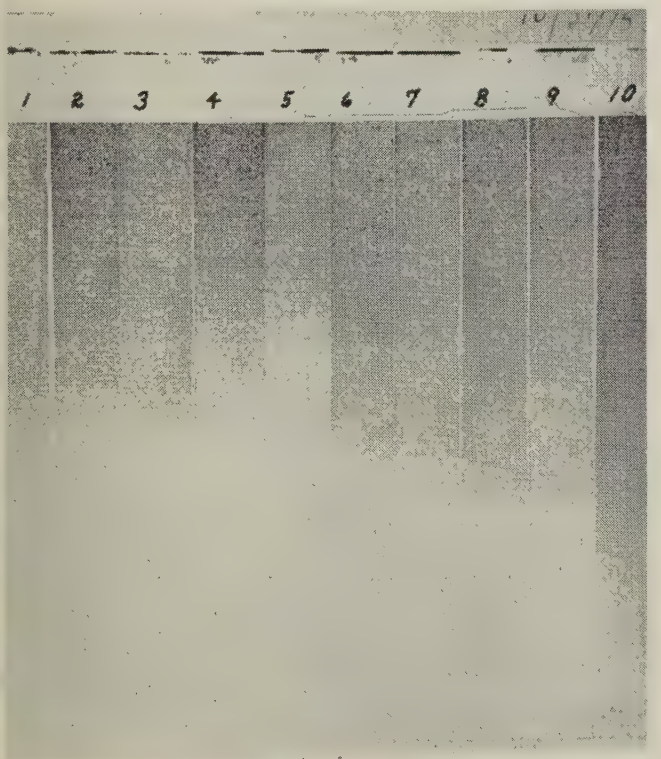



*Fig. 4. Typical drying record chart for I.G.T. recorder*

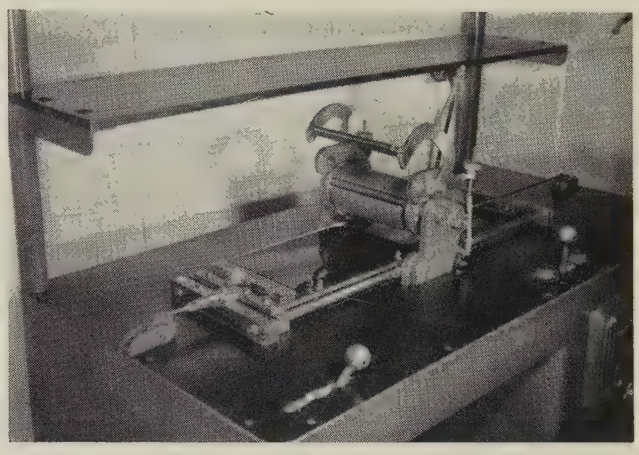


*Fig. 5. The rotary pick tester*

*reaches the above determined zero ink level.* This length can be directly converted to time after printing of the paper in terms of the age of the print at the start of the drying test, and the rotational speed of the recorder drum. This length can be reproducibly located to within ±1 mm. along the chart, corresponding to a time uncertainty of about ±2 min. for a recorder cycle of 4.5 hr., and ±15 min. on a cycle of 68 hr. End points of ink drying determined in the above manner agree well with qualitative judgments of printed film indelibility.

## PREPARATION OF PAPER PRINTS

Where data are to be accumulated over a period of time involving a large number of comparative tests, a standard method of printing is essential. Printing variables to be controlled are the impression load, the paper backing material, the printing film thickness, uniformity of the printing plate, the printing speed, and the ink temperature. This has been

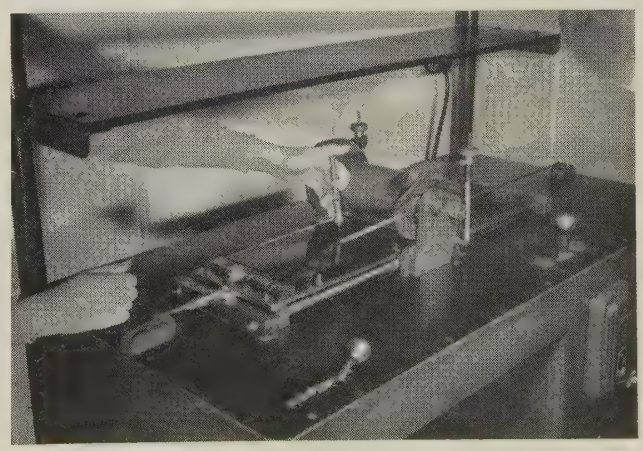


*Fig. 6. The rotary pick tester; film application*

**Table II. I.G.T. Recorder Ink Drying Times for 10 Letterpress Papers and 17 Inks (Hours After Printing)**

| Paper sample | Ink 1 | Ink 2 | Ink 3 | Ink 4 | Ink 5 | Ink 6 | Ink 7 | Ink 8 |
|---|---|---|---|---|---|---|---|---|
| A Wire | 2.8 | 1.7 | 2.2 | 3.7 | 2.0 | 1.3 | 3.0 | 3.4 |
| Felt | 2.7 | 1.2 | 2.8 | 3.8 | 2.0 | 1.2 | 2.9 | 2.3 |
| B Wire | 3.0 | 1.8 | 2.7 | 4.0 | 2.1 | 0.8 | 4.0 | 3.2 |
| Felt | 3.2 | 1.3 | 2.4 | 4.1 | 2.2 | 1.2 | 3.7 | 2.8 |
| C Wire | 2.8 | 1.2 | 2.4 | 4.2 | 1.8 | 0.6 | 3.8 | 3.2 |
| Felt | 3.1 | 1.5 | 3.1 | 3.8 | 2.1 | 1.1 | 3.6 | 1.9 |
| D Wire | 2.9 | 1.7 | 2.5 | 4.0 | 2.0 | 1.0 | 4.0 | 3.2 |
| Felt | 3.1 | 1.5 | 3.2 | 4.1 | 2.2 | 1.7 | 3.5 | 2.8 |
| E Wire | 2.8 | 1.7 | 2.5 | 4.5 | 2.2 | 1.0 | 3.9 | 3.5 |
| Felt | 3.3 | 1.5 | 3.3 | 3.9 | 2.2 | 1.5 | 3.6 | 3.1 |
| F Wire | 3.0 | 1.8 | 3.1 | 4.6 | 2.9 | 1.3 | 4.2 | 3.9 |
| Felt | 3.4 | 1.9 | 4.0 | 4.2 | 3.2 | 2.1 | 3.9 | 3.6 |
| G Wire | 3.1 | 1.9 | 2.9 | 4.4 | 2.7 | 1.7 | 4.3 | 3.8 |
| Felt | 3.7 | 1.7 | 3.6 | 4.3 | 2.9 | 1.5 | 3.9 | 3.3 |
| H Wire | 3.5 | 1.8 | 2.8 | 4.6 | 2.3 | 1.3 | 4.2 | 3.8 |
| Felt | 3.3 | 1.8 | 3.8 | 4.2 | 2.4 | 1.5 | 3.9 | 3.2 |
| I Wire | 3.2 | 1.8 | 2.9 | 4.5 | 2.5 | 1.9 | 4.3 | 3.8 |
| Felt | 3.6 | 1.8 | 3.8 | 4.3 | 2.4 | 1.6 | 4.0 | 3.2 |
| J Wire | 3.3 | 1.8 | 2.7 | 4.1 | 2.3 | 1.2 | 4.2 | 3.7 |
| Felt | 3.8 | 1.7 | 3.4 | 4.5 | 2.4 | 1.8 | 3.5 | 2.9 |
| Ten-paper av. | 3.18 | 1.66 | 3.05 | 4.19 | 2.34 | 1.36 | 3.82 | 3.23 |
| Extremes | 2.7–3.8 | 1.2–1.9 | 2.2–4.0 | 3.7–4.6 | 1.8–3.2 | 0.6–2.1 | 2.9–4.3 | 1.9–3.9 |

| Paper sample | Ink 9 | Ink 10 | Ink 11 | Ink 12 | Ink 13 | Ink 14 | Ink 15 | Ink 16 | Ink 17 |
|---|---|---|---|---|---|---|---|---|---|
| A Wire | 1.0 | 0.5 | 10.3 | 1.6 | 2.9 | 2.7 | 8.5 | 2.0 | 2.0 |
| Felt | 0.6 | 0.8 | 7.3 | 1.6 | 2.9 | 2.5 | 6.5 | 2.2 | 2.0 |
| B Wire | 0.8 | 0.2 | 11.0 | 2.0 | 3.5 | 3.2 | 10.0 | 2.2 | 2.0 |
| Felt | 0.4 | 0.5 | 9.2 | 1.8 | 3.2 | 3.2 | 6.5 | 2.5 | 2.3 |
| C Wire | 0.7 | 0.2 | 8.5 | 1.8 | 3.4 | 3.1 | 9.5 | 2.0 | 1.7 |
| Felt | 0.5 | 0.5 | 9.0 | 1.7 | 3.3 | 3.0 | 6.0 | 2.3 | 2.1 |
| D Wire | 0.3 | 0.2 | 8.0 | 1.9 | 3.7 | 3.1 | 11.4 | 2.7 | 2.1 |
| Felt | 0.4 | 0.6 | 10.0 | 1.8 | 3.5 | 3.1 | 6.4 | 2.9 | 2.3 |
| E Wire | 0.2 | 0.2 | 8.6 | 2.1 | 3.2 | 3.9 | 7.5 | 2.2 | 2.4 |
| Felt | 0.2 | 0.6 | 7.3 | 1.8 | 3.4 | 3.1 | 5.7 | 3.4 | 2.8 |
| F Wire | 0.8 | 0.8 | 13.7 | 2.2 | 3.7 | 3.7 | [a] | 3.0 | 3.2 |
| Felt | 0.8 | 0.8 | 11.1 | 2.2 | 3.9 | 3.3 | 6.9 | 3.0 | 2.5 |
| G Wire | 1.0 | 1.0 | 10.3 | 2.2 | 3.6 | 3.8 | 9.1 | 3.1 | 2.8 |
| Felt | 0.4 | 0.8 | 9.5 | 2.2 | 3.8 | 3.5 | 6.8 | .. | .. |
| H Wire | 1.4 | 1.0 | 10.5 | 2.2 | 3.5 | 3.7 | 9.1 | 3.0 | 2.8 |
| Felt | 1.0 | 1.0 | 9.2 | 2.0 | 3.7 | 3.2 | 6.2 | 3.5 | 2.5 |
| I Wire | 1.4 | 1.8 | 10.2 | 2.2 | 3.7 | 3.8 | 9.2 | 3.2 | 3.2 |
| Felt | 0.9 | 2.8 | 8.5 | 2.1 | 3.6 | 3.5 | 6.8 | 2.6 | 2.8 |
| J Wire | 1.1 | 0.7 | 7.8 | 2.0 | 3.2 | 3.2 | 8.4 | 2.6 | 2.6 |
| Felt | 0.6 | 1.2 | 8.2 | 1.9 | 2.9 | 3.6 | 6.5 | 2.6 | 2.5 |
| Ten-paper av. | 0.72 | 0.81 | 9.41 | 1.96 | 3.43 | 3.31 | 7.74 | 2.68 | 2.45 |
| Extremes | 0.2–1.4 | 0.2–2.8 | 7.3–13.7 | 1.6–2.2 | 2.9–3.9 | 2.5–3.9 | 5.7–11.4 | 2.0–3.5 | 1.7–3.2 |

[a] Beyond 12 hr.

best accomplished with a bench-type press in preference to a commercial type letterpress.

For the tests here reported, papers were printed in the Kimberly-Clark rotary pick tester described earlier by W. W. Roehr (*1*), and shown in Figs. 5 and 6. Briefly, the instrument resembles a flat-bed cylinder press. Solid prints are obtained on 5.5 by 11-in. paper specimens, printed from a 0.5-in. glass plate. The temperature of the plate remains constant at 72° ± 2°F. during testing. Uniform films of ink ranging from about 2.5 to 10 mu on the glass plate are conveniently obtained by adjustment of the load on the film metering bar shown raised in Fig. 5 and lowered in Fig. 6. A printing thickness on the glass plate of 3.5 ± 0.5 mu serves as a suitable standard, and is measured directly with an Interchemical wet film thickness gage.*

The air-draulic loading system of the impression cylinder was maintained at 141 ± 5 lb., giving an average nip pressure of 100 ± 3 p.s.i. for a nip width of 0.24 in.

The glass printing plate travels at constant speed for metering the film, but accelerates with distance traveled from 0 to 60 cm. per sec. during the impression stroke. While a uniform impression speed would be more desirable for the present application, it has been found that the small variation in thickness of the ink film transferred to the paper as the plate accelerates is of little consequence when dealing with coated

* Manufactured by the Henry A. Gardner Laboratories, Bethesda, Md.

**Table III. Reproducibility of Ink Drying Tests on Seven Different Days**

| Paper sample | I.G.T. recorder ink drying time, hr. 1 | 2 | 3 | 4 | 5 | 6 | 7 | Average | Extremes |
|---|---|---|---|---|---|---|---|---|---|
| A | 1.29 | 1.50 | 1.85 | 1.49 | 1.61 | 1.69 | 1.50 | 1.56 | 1.29–1.85 |
| B | 1.16 | 1.23 | 0.96 | 0.89 | 1.08 | 1.13 | 0.88 | 1.05 | 0.88–1.23 |
| C | 0.92 | 0.93 | 0.97 | 1.22 | 1.14 | 1.03 | 0.75 | 0.99 | 0.75–1.22 |
| D | 1.73 | 1.74 | 1.62 | 1.71 | 1.74 | 1.53 | 1.63 | 1.67 | 1.53–1.74 |
| E | 1.44 | 1.28 | 1.39 | 1.29 | 1.28 | 1.25 | 1.26 | 1.31 | 1.25–1.44 |
| F | 2.04 | 1.37 | 1.79 | 1.65 | 1.50 | 1.60 | 1.37 | 1.62 | 1.37–2.04 |
| G | 1.50 | 1.57 | 1.67 | 1.64 | 1.55 | 1.70 | 1.59 | 1.60 | 1.50–1.70 |
| H | 1.51 | 1.60 | 1.77 | 1.67 | 1.60 | 1.55 | 1.63 | 1.62 | 1.51–1.77 |
| I | 1.60 | 1.65 | 2.03 | 1.79 | 1.75 | 1.71 | 1.64 | 1.74 | 1.60–2.03 |
| J | 1.83 | 1.59 | 1.84 | 1.78 | 1.71 | 1.66 | 1.75 | 1.74 | 1.59–1.84 |

Ink 6; printing film = 4.5 ± 0.4 mμ. Papers printed on felt side.

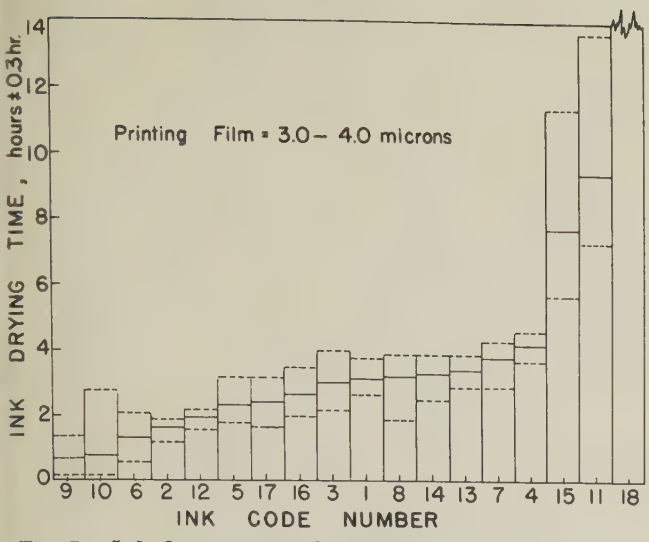



*Fig. 7. Ink drying times for 18 letterpress inks and 10 papers*

Solid bar = 10-paper composite average (wire and felt). Dotted bar = 10-paper extremes.

book papers and regular letterpress inks. The early portion of the print, at the slowest speeds, is not used for the drying record.

Supplementary to ink drying time tests on papers printed with the bench instrument, drying tests were run with papers printed in commercial type platen and flat-bed cylinder press equipment using the same inks. In general, good agreement with the bench prints is obtained when the printing film thickness is matched. With commercial press equipment precise control of the major printing variables becomes difficult. Such tests are also time consuming and require additional personnel.

## DATA AND OBSERVATIONS

Table II shows a typical set of ink drying time data for the ten papers earlier mentioned, printed wire and felt sides with 17 letterpress halftone black inks according to the procedures outlined above. (Printing and drying at 50 ± 3% R.H., 72 ± 2°F.) Drying times here shown are reproducible to within about ±0.3 hr. for repetitive tests with sheets of the same samples. Table III shows typical reproducibility obtained between days for a fast drying ink. Charts for the slower drying inks are less subject to errors in end-point determinations.

The data of Table II are reproduced in Fig. 7, showing the wire and felt side composite average and extremes for the ten papers and 17 inks. The spread in ink drying times for three of the inks and the ten papers is shown in Fig. 8.

It becomes clear that the ink drying time for a given paper, tested under the standard conditions here established, is subject to broad variation depending upon the choice of test ink. Differences between the papers appear to be relatively small by comparison.

Further evidence of the above are illustrated in Figs. 9 and 10. Note in Fig. 9 that ink no. 20 dries hard in about 2 hr., while ink no. 18 shows an appreciable set-off 12 days after

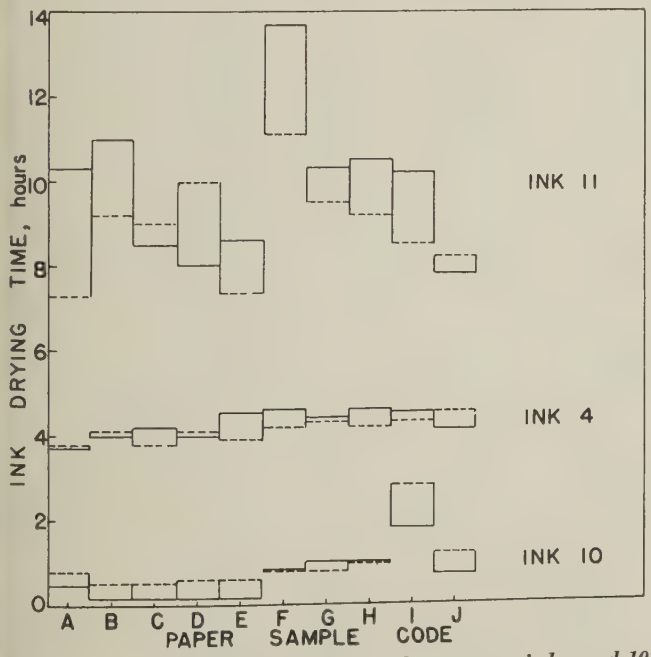



*Fig. 8. Ink drying times for three letterpress inks and 10 papers tested wire and felt sides*

Solid bar = wire side. Dotted bar = felt side.

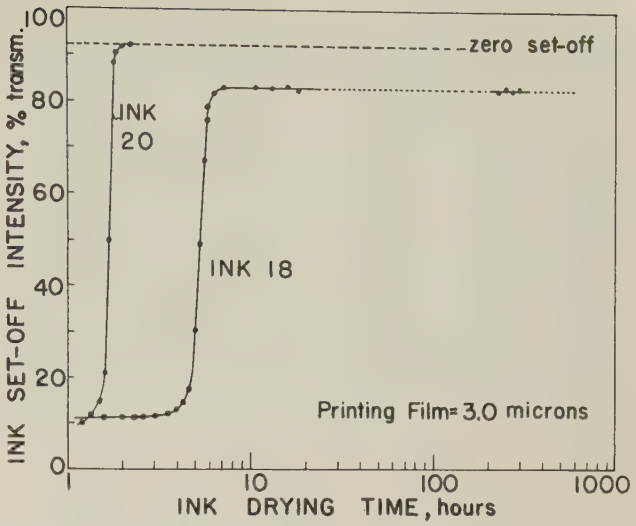



*Fig. 9. Drying behavior of two letterpress halftone black inks printed on the same paper (sample H)*

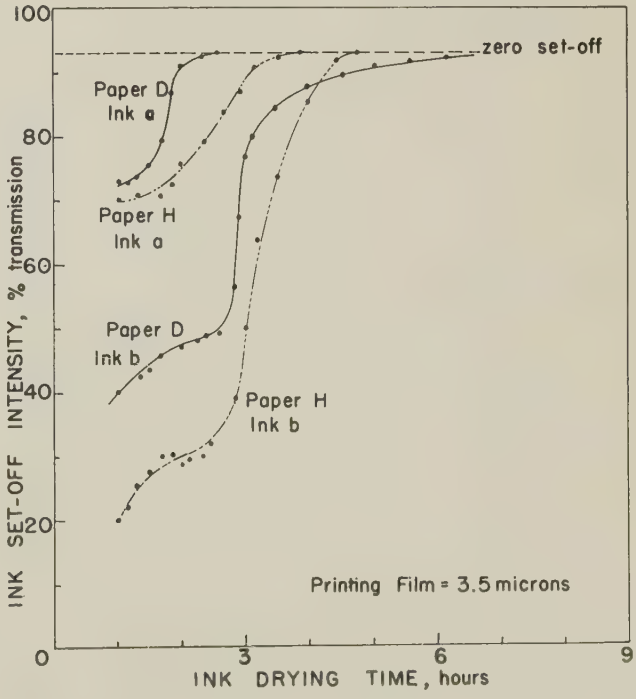

zero set-off
Paper D Ink a
Paper H Ink a
Paper D Ink b
Paper H Ink b
Printing Film = 3.5 microns
INK SET-OFF INTENSITY, % transmission
INK DRYING TIME, hours

*Fig. 10. Observed changes in ink drying behavior for two papers and two inks*

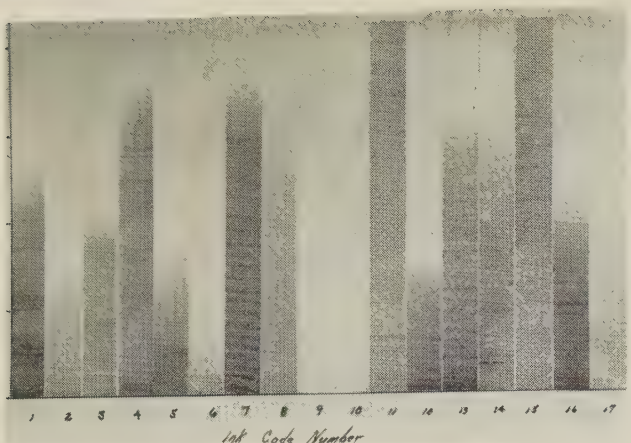



*Fig. 11. Ink set-off records on acetate for 17 inks and paper sample H*

printing with no indication of further improvement. Figure 10 illustrates a serious change in the relative ink drying behavior of two papers when printed with two inks. Figure 11 offers a visual comparison of differences in ink set-off recorded on acetate by the I.G.T. drying recorder for a single paper and 17 inks.

Table IV will give some indication that the paper prints of the type tested in Table II are of similar apparent blackness. The blackness values were obtained with the Bausch and Lomb Opacimeter with the paper specimen directly over the instrument aperture, printed side down. The same scale deflection was obtained for either the white or black body backing the paper print.

Table V shows that a considerably broader spread occurs in the instrumental gloss of the dried prints measured at 75° in the Kimberly-Clark glossmeter described by Zabel and Wink (*2*). Note that depending upon the choice of ink, the printed gloss varies from well below to well above the unprinted paper level.

It has become clear during the present work that a direct

**Table V. 75° Specular Gloss Comparison of Unprinted and Printed Paper for 10 Papers, 15 Inks**

| *Paper sample code* | *Side tested* | *75° K-C gloss, %[a]* *Unprinted* | *Printed 15-ink range* |
|---|---|---|---|
| A | Wire | 58 | 32–67 |
| | Felt | 58 | 29–79 |
| B | Wire | 59 | 34–83 |
| | Felt | 59 | 30–86 |
| C | Wire | 60 | 37–84 |
| | Felt | 61 | 34–84 |
| D | Wire | 71 | 43–86 |
| | Felt | 75 | 38–87 |
| E | Wire | 59 | 31–80 |
| | Felt | 57 | 27–72 |
| F | Wire | 53 | 33–73 |
| | Felt | 52 | 29–68 |
| G | Wire | 57 | 34–71 |
| | Felt | / | / / |
| H | Wire | 51 | 31–80 |
| | Felt | 54 | 33–71 |
| I | Wire | 46 | 34–73 |
| | Felt | 42 | 33–69 |
| J | Wire | 53 | 31–89 |
| | Felt | 54 | 30–91 |

[a] Relative to 100% for black glass standard.

relation does not exist between the setting properties of an ink judged a short time after printing and the end point of ink drying. As shown in Fig. 12, two papers printed with the same ink may show wide variation in early set-off, but exhibit nearly the same end point of drying.

A factor which aggravates ink drying paper tests as here described is that some inks will change noticeably in drying properties over relatively short periods of storage after manufacture. Serious changes in some inks have been observed within three months after manufacture. Figure 13 illustrates this effect for one sample of ink tested 1 month and 1 year after the manufacturer's date on the cans. Empirically, the ink seems to have lost some of its binding properties, giving rise to a poorly bonded pigment film on the paper surface.

It would appear desirable to check periodically the drying of the test inks printed on some standard surface other than

**Table IV. B. & L. Opacimeter Blackness of Print for 10 Papers and 16 Inks**

| *Paper sample Code* | *Opacimeter blackness of print, %[a] Ink code number* *1* | *2* | *3* | *5* | *6* | *7* | *8* | *9* |
|---|---|---|---|---|---|---|---|---|
| Wire side | | | | | | | | |
| A | 6.6 | 6.0 | 6.0 | 7.3 | 4.8 | 6.2 | 6.2 | 5.4 |
| B | 6.3 | 6.0 | 5.6 | 7.0 | 5.2 | 6.0 | 5.8 | 5.0 |
| C | 6.5 | 6.0 | 5.8 | 7.0 | 5.1 | 6.1 | 6.2 | 5.2 |
| D | 6.0 | 6.0 | 5.5 | 6.8 | 5.5 | 5.8 | 5.7 | 5.0 |
| E | 6.6 | 6.1 | 5.8 | 7.0 | 5.6 | 6.2 | 6.2 | 5.2 |
| F | 6.4 | 6.0 | 6.0 | 7.2 | 5.0 | 6.2 | 6.3 | 5.1 |
| G | 6.4 | 5.8 | 5.9 | 7.4 | 5.0 | 6.2 | 6.4 | 5.6 |
| H | 6.8 | 6.0 | 6.0 | 7.4 | 5.4 | 6.3 | 6.6 | 5.0 |
| I | 6.9 | 5.8 | 6.2 | 7.4 | 4.8 | 6.3 | 7.1 | 5.3 |
| J | 6.4 | 6.0 | 5.9 | 7.2 | 4.8 | 6.3 | 6.2 | 5.0 |
| Ten-paper av. | 6.5 | 6.0 | 5.9 | 7.2 | 5.1 | 6.2 | 6.3 | 5.2 |
| Extremes | 6.0–6.9 | 5.8–6.1 | 5.5–6.2 | 6.8–7.4 | 4.8–5.6 | 5.8–6.3 | 5.7–7.1 | 5.0–5.6 |

| *Paper sample Code* | *Opacimeter blackness of print, %[a] Ink code number* *10* | *11* | *12* | *13* | *14* | *15* | *16* | *17* | *Extremes* |
|---|---|---|---|---|---|---|---|---|---|
| Wire side | | | | | | | | | |
| A | 6.3 | 6.8 | 6.1 | 6.0 | 5.8 | 6.0 | 7.1 | 7.0 | 4.8–7.1 |
| B | 6.4 | 6.6 | 5.0 | 6.3 | 5.6 | 5.8 | 6.6 | 7.6 | 5.0–7.6 |
| C | 6.1 | 6.8 | 6.0 | 6.2 | 5.6 | 6.0 | 6.8 | 7.0 | 5.1–7.0 |
| D | 6.1 | 6.6 | 5.7 | 6.3 | 5.2 | 5.8 | 6.4 | 6.2 | 5.0–6.8 |
| E | 6.7 | 6.8 | 6.0 | 6.0 | 5.8 | 6.0 | 6.9 | 7.8 | 5.2–7.8 |
| F | 6.6 | 6.8 | 6.1 | 5.8 | 5.8 | 6.1 | 7.2 | 6.5 | 5.0–7.2 |
| G | 6.4 | 7.0 | 6.0 | 5.9 | 5.7 | 6.3 | 7.4 | 6.1 | 5.0–7.4 |
| H | 7.2 | 6.9 | 6.2 | 5.9 | 5.8 | 6.1 | 7.3 | 7.1 | 5.0–7.4 |
| I | 6.9 | 7.0 | 6.2 | 5.4 | 5.8 | 6.2 | 7.6 | 6.4 | 4.8–7.6 |
| J | 6.4 | 6.8 | 6.2 | 5.9 | 5.9 | 6.0 | 7.0 | 8.0 | 4.8–8.0 |
| Ten-paper av. | 6.5 | 6.8 | 6.0 | 6.0 | 5.7 | 6.0 | 7.0 | 7.0 | |
| Extremes | 6.1–7.2 | 6.6–7.0 | 5.0–6.2 | 5.4–6.3 | 5.2–5.9 | 5.8–6.3 | 6.4–7.6 | 6.1–8.0 | |

[a] Relative to 100.0 for white standard, and 0.0 for black cavity.

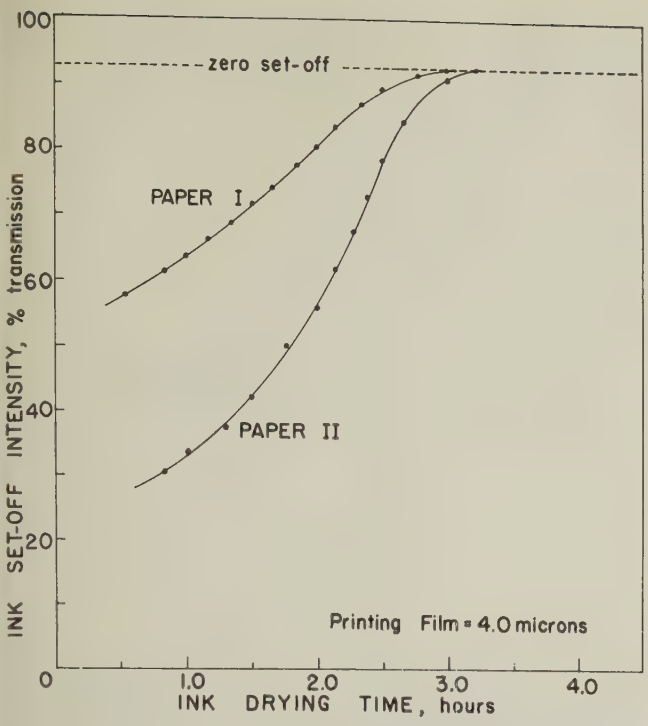



*Fig. 12. Relative ink set-off behavior as determined with the I.G.T. drying recorder for two papers printed with the same ink*

paper, such as glass or metal foil. Thus far, the possibility of printing 0.003-in. cellulose acetate in the rotary pick tester shows some promise. However, complicating factors arise in that very poor agreement is observed between drying on the acetate and on paper. This is illustrated by Fig. 14. Apparently certain inks which will harden on a smooth, non-absorbent surface may lose dryer or binder components to the paper stock, resulting in a poorly bonded film on the paper surface. For example, ink 18 dries on the acetate in about 18.5 hr., while the drying on paper is not complete several days after printing.

The importance of careful selection and control of the printing film thickness is illustrated by Fig. 15. While one would expect the drying time on paper to increase somewhat with the printing film thickness, a curious result is obtained when printing at very thin films. For several of the inks and papers examined it has been found that decreasing the printing film thickness below a critical level results in *increased* ink drying times on the paper. This effect appears related to the particular combination of ink viscosity, ink drying rate, and the absorbency potential of the paper. At very thin films there may be sufficient absorption of binder and dryer components from the ink to prevent proper hardening of the residual film over the paper surface.

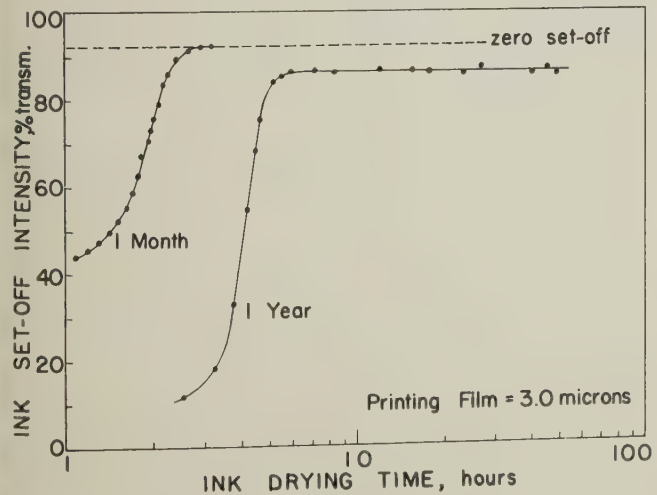



*Fig. 13 Effect of aging at 50% R.H., 72°F. on drying behavior of ink No. 5 and paper sample H*

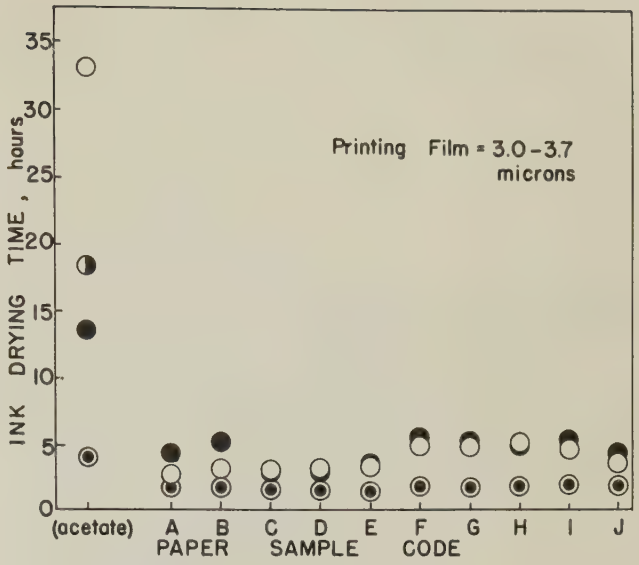



*Fig. 14. Comparison of ink drying time on cellulose acetate with drying times for ten papers*

○ ink 27. ◑ ink 18. ● ink 19. ◉ ink 20.

In departing from the standard conditions of 50% R.H., 72°F. used for the comparative drying tests here discussed, it is easily shown that ink drying times on paper for a given ink-paper combination tend to increase as the relative humidity of the drying atmosphere is raised. This affect is illustrated in Fig. 16 for eight papers and ink no. 19. Note the pronounced reduction in ink drying time for each of the papers at 75% R.H., 75°F. when a small amount of a cobalt dryer is added to the ink. Depending somewhat on the original dryer content of the ink, most inks of the drying oil type require additional drier at high relative humidities.

Raising the air temperature of the drying atmosphere without raising the air moisture level above that at 50% R.H., 72°F. results in a substantial decrease in ink drying times on

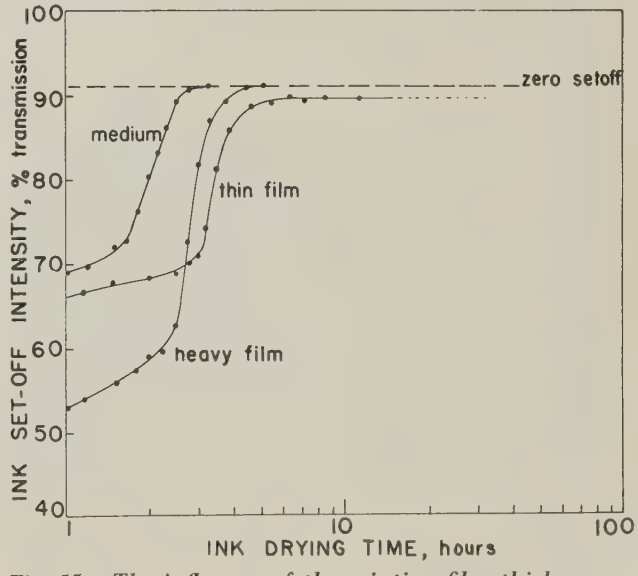



*Fig. 15. The influence of the printing film thickness on the drying time of ink on paper*

Heavy film: 7 mu, or more. Medium film: 3 → 5 mu. Thin film: 2 mu, or less.

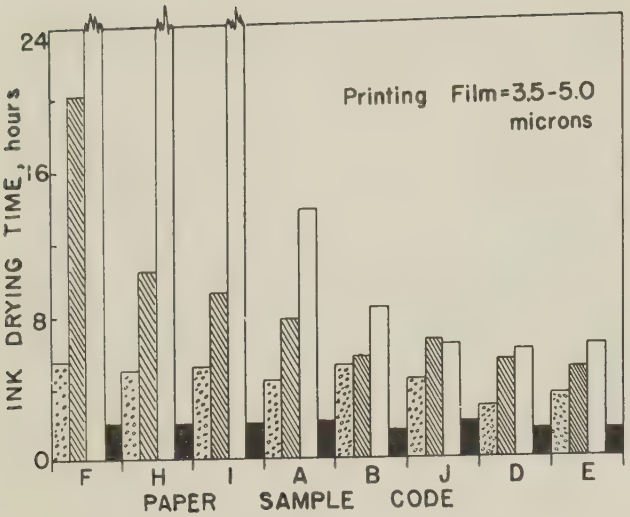



*Fig. 16. Influence of high relative humidity on ink drying time for letterpress ink No. 19 and 8 papers*

- dried at 50% R.H., 72° F.
- dried at 75% R.H., 75° F.
- preconditioned and dried at 75% R.H., 75° F.
- dried at 75% R.H., 75° F. 6% cobalt drier added to ink

the ten papers tested with several of the inks. For example, raising the temperature to 100°F. reduces the ink drying times observed at 72°F., 50% R.H. by factors ranging from 0.37 to 0.55. Such considerations are of importance where heat is applied at the delivery end of a commercial press to assist setting and drying of the ink. (Delivery pile temperatures above 95°F. have been observed several hours after printing where individual sheets were exposed to a temperature of 140°F. for about 1 sec. during printing.)

## CONCLUSION

The present work, largely of a survey nature, provides valuable orientation material for paper research and quality control applications regarding ink drying problems. The principal findings are summarized below.

1. The I.G.T. drying time recorder together with standard conditions for printing allows an objective approach to ink-paper drying relationships.
2. Considerable care must be exercised in selecting test inks for drying tests.
3. Comparative paper tests with a single test ink can be quite misleading as regards the commercial ink drying performance of the paper.
4. The printing film thickness, relative humidity, and temperature have a critical effect on ink drying on paper.

Drying tests with the I.G.T. recorder are being extended to include paper specimens printed on commercial type letterpress equipment where sheets dried in free air are compared with sheets pulled from the delivery pile. Results obtained thus far are in good agreement with the bench tests here described. From the paper research standpoint, considerable deviation from the above described methods proves interesting. For paper quality analysis, the I.G.T. drying recorder appears to be both a sensitive and simple instrument for use by the nonprofessional laboratory technician.

## LITERATURE CITED

1. Roehr, W. W., *Tappi* 34, No. 11: 525–528 (1951).
2. Zabel, L. W., and Wink, W. A., *Tappi* 37, No. 10: 474–480 (1954).

The author wishes to acknowledge helpful suggestions from W. W. Roehr during the present work.

A C. J. West Award paper presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., April 12, 1955.

# Photographic Techniques for Paper Surface Study

JOHN C. NELSON

In the manufacture of reproduction papers such as that produced at the author's mill, the evenness of the paper surface is paramount. This paper deals with the development of a technique for the study of the paper surface. The development was necessary to bring about improvements in manufacturing.

Why this evenness of surface is so important can be explained very easily. To get a finished reproduced copy without specks or spots of varying color depth, the sensitized coating applied to the base stock must be received and retained evenly on the surface. To attain this homogeneity of coating the surface must be relatively free from irregularities of a topographical variety. The better the surface the the fewer and the shallower the depressions, hence the better the coating and the better the finished copy.

When a sheet of uncoated paper is viewed under very low power magnification, such as a hand magnifier, a certain amount of roughness is visible. By viewing this same paper under higher magnification, such as a low-power microscope would give, these irregularities appear to reach hill and valley proportions. If the light used for viewing the specimen is allowed to come from a source on a level with the sheet or parallel to it, rather than from below the sheet, the light rays will be cast across the surface of the paper. This method of lighting will cause the hills and valleys of the surface to appear as lighter and darker areas.

The depressions on the surface appear as darker areas because they are actually shadows. The high spots of the surface appear as transparents or light spots since they receive the most intense light.

If the magnification does not exceed 100 diameters the viewer will get an excellent perspective of a rather large surface area of the sheet. If the magnification is increased the field of view is reduced so that at higher powers this would become a fiber study rather than a surface study. This area of paper, viewed under low power magnification with the light parallel to the surface and cast across the sheet, is what the author means by "microsurface."

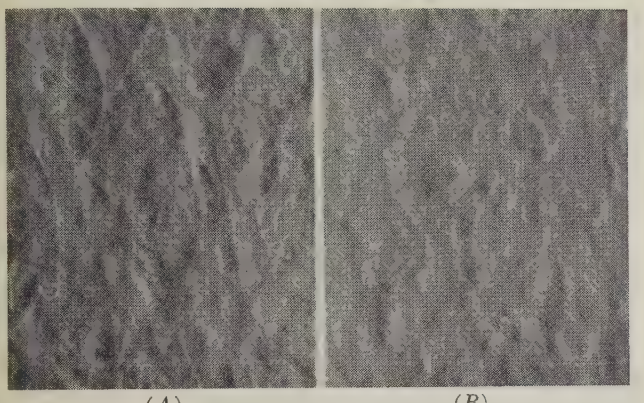
A Bausch and Lomb model 39A microphotography attachment was the first equipment used. The attachment consists of a shutter and lens with a focusing barrel in one unit and a simple box-type camera that can take a film pack or loaded single filmholders. To place in operation, the ocular of the microscope is removed and the camera put in position. The ocular is replaced and the specimen can be viewed through the focusing barrel. By operating the cable release the picture can be taken at any shutter speed up to $^1/_{100}$ of a second. Ordinary cameras with adaptations can be used instead of the type supplied with the attachment.

This was used in connection with a Bausch and Lomb model SKW stereomicroscope. Magnifications from 5 to 20 diameters are possible.

With this arrangement it was very difficult to get enough light across the surface to make focusing through the barrel possible. After experimentation with low-watt lamps, a pair of 500-watt photoflood lamps were employed. This enabled us to view our surface fairly well. The amount of heat radiated from a pair of photofloods within 6 in. of the microscope had to be dealt with, however.

An encasement of heavy cardboard was made for the photoflood lamps and lined with sheet asbestos. The inside surfaces were covered with aluminum foil to give as much re-

John C. Nelson, Fox River Paper Corp., Appleton, Wis.



(A). (B).

***Fig. 1. Bausch and Lomb model 39A camera***

(A) Microsurface of sheet prior to improvements. (B) Microface of sheet after improvements. (Both pictures taken and processed identically. Both papers same grade and weight.)

flection as possible. The asbestos, of course, kept the entire set-up from bursting into flames.

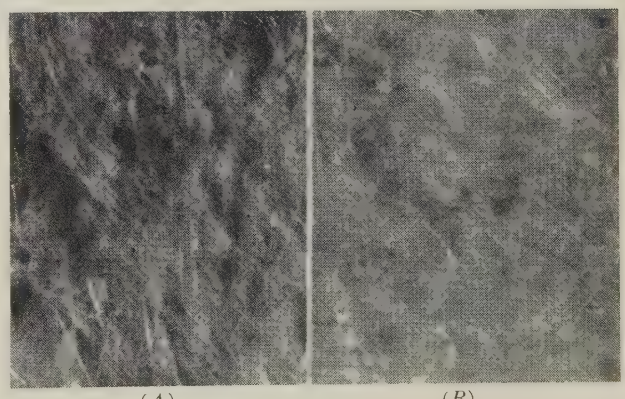
The heat resulting from the lamps caused the sample specimens of paper to curl. In one or two cases the paper actually charred during the photographing operation. To keep the surface absolutely flat and the resultant picture in focus in all areas the specimen was mounted under a thin sheet of glass. The original thought that glass would cause reflections on the film and also somewhat reduce the light intensity, was found to be untrue. Some fairly acceptable pictures were taken with this arrangement. Ordinary gloss prints were made from the negatives.

Attempts at surface pictures were next made with the use of an ordinary commercial copying camera. To attain the desired magnification the negatives were enlarged several times. The resultant prints exhibited so much graininess they were of little value. Even the use of very fine grain films brought little success. This method of picture taking was shortly abandoned.

After 5 months we had succeeded in making a permanent record of our paper microsurfaces. One method of photographing was of little value for this work. The other method was moderately successful. In surveying the completed work it was felt that to succeed in obtaining photos with better contrast and sharper definition some other types of camera equipment must be employed.

The Universal Foundry Co. of Oshkosh was kind enough to let us use their Bausch and Lomb model H microphotography camera. For the assistance of Richard Miller and John Ziebell the author is indebted. Only through their interest and cooperation was the balance of this developmental work made possible.

This camera was mounted on an adjustable stand and focused through a model CM7 Bausch and Lomb metallurgical microscope. Film plates of 5 by 7 in. replace the ground glass focusing plate when the picture is to be taken.



(A) (B)

***Fig. 2. Bausch and Lomb model H camera***

(A) Microsurface of sheet prior to improvements. (B) Microsurface of sheet after improvements. Lighter over-all color is a function of the increased evenness of surface. (Both pictures taken and processed identically. Both papers same grade and weight.)

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Operation of this equipment was very simple. No modifications were necessary to alter the set-up as regards the nature of the specimen. Pictures are pictures! Even though the sample to be photographed was paper rather than metal, the results were very good.

The hazy focus was gone. The ground-glass plate made previewing of the sample surface very easy. The image was sharp and clear with only 150 watts of illumination across the surface of the specimen. Magnification diameters were changed by easily removed objective lenses. Extension of the bellows controlled the area of the film plate exposed. The only questionable fact in the use of this equipment was the high magnification ultimately used. The pictures were taken at about 80 diameters. It can be seen by the accompanying photos that the quality was superior to any taken prior to the use of this camera.

Significant changes in manufacturing methods resulted from this technique. A basis weight gage was put in operation to record "on-the-machine" changes. This reduced the possibilities of more evident weight and caliper variations. The moisture of the finished sheet was more closely controlled to aid in reducing galvanizing. Furnish additions and modifications were made until the surface showed evidence of fewer irregularities, due in part to the pliability of the fibers. Substantial alterations and additions were made in wet pressing. Together these changes made the microsurface unusually good as regards the acceptance of the sensitized coating.

Just as the quality of reproduction papers depend on smoothness of coating, so does the quality of printing paper depend upon its ink receptivity. Both types of paper require a superior microsurface. The level of this superiority rises only when the paper surface has been attentively studied and this study has become the able assistant it can be in making decisions toward manufacturing improvements.

A C. J. West Award paper presented at a meeting of the Lake States Section of the Technical Association of the Pulp and Paper Industry, Appleton, Wis., April 12, 1955.

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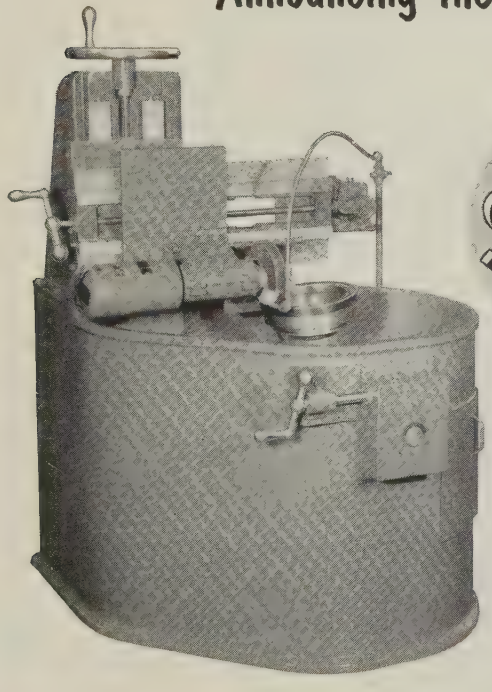

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# THE UTILIZATION OF SPENT SULPHITE LIQUOR

## *A Bibliography of the Literature Published During 1954*

H. BORDEN MARSHALL and ANN I. MacDONALD

### AMMONIA-BASE PROCESS

CROWE, G. A., *Tappi* 37, No. 3; 154A–156A (1954); *C.A.* 48: 6118 (1954).

Ammonia-base bisulphite cooking has many advantages over other bases: it gives increased pulp yields of good quality, shortens the cooking time by at least 1 hr. (a mixture of beech, birch, and maple can be cooked in about 7 hr.), the use of a small amount of hardwood will pay for the increased cost of the ammonia base, and the bleaching time and bleach requirement can be reduced.

LAFOND, L. A., *Paper Mill News* 77, No. 12: 90, 100 (1954); *C.A.* 48: 6694 (1954).

After 3.5 years of operational experience with ammonia-base sulphite cooking liquor, a comparison was made with the calcium and dolomite acid procedures. Despite the fact that ammonia costs twice as much as calcium oxide, there was a saving of about 40 lb. S per ton of pulp with ammonia-base sulphite cooking liquor, which also gave a more uniform operation than did the calcium and dolomite acid procedures. Pulp yields and overall production increased because of shorter cooking schedules with ammonia-base sulphite cooking liquor. The percentage of screenings with ammonia-base sulphite cooking liquor decreased, and the pulp was more readily screened and bleached. On the other hand with ammonia-base sulphite cooking liquor, slime growth increased markedly; this could be controlled by the regular use of various slimicides, together with a complete "boil-out" of the system three times per annum. In general, ammonia-base sulphite cooking liquor requires less maintenance than does the calcium and dolomite acid procedures.

HULL, J. H., *Paper Mill News* 77, No. 12: 64, 68 (1954); *C.A.* 48: 6694 (1954).

This report is based on pilot-plant studies and on the (still inconclusive) results obtained at the Lebanon mill in Oregon. Blow-pit washing is used for the recovery of liquor, which is concentrated to 50% solids in a two-effect Rosenblad evaporator and then burned under two boilers, only one of which is equipped for the recovery of sulphur. The latter is effected by scrubbing the flue gases with 17% $NH_4OH$. The scrubbing solution serves as "raw acid" in the acid plant. The pilot-plant operation dealing with liquor from 10 tons of pulp per diem, indicated that enough steam could be made available for total liquor evaporation and that 80 to 85% of the sulphur was recoverable.

MCGREGOR, G. H., *Paper Ind.* 36: 150–151 (1954); *C.A.* 48: 7898 (1954).

A descriptive article which deals with calcium, magnesium, sodium, and ammonia-base sulphite pulping. The ammonia-base process, both with and without liquor recovery, presents advantages which are described briefly.

OGIWARA, Y., *J. Japan Tech. Assoc. Pulp & Paper Ind.* 7, No. 5: 2–9 (1953); *C.A.* 48: 8540 (1954).

The practical temperature in neutral ammonium sulphite process was 160 to 180°, and the best results were obtained at 165 to 170°. Although the cooking was performed under neutral conditions, a remarkable destruction of cellulose and hemicellulose took place because of the relatively high cooking temperature as compared with that of the ordinary sulphite process. The yield of pulp was 52 to 53% (Roe no. 10); that of holocellulose was 92 to 93%. A part of the ammonia used was combined with organic compounds in waste liquor and was not liberated by alkali.

OGIWARA, Y., *J. Japan Tech. Assoc. Pulp & Paper Ind.* 7, No. 5: 10–18 (1953); *C.A.* 48: 8540 (1954).

A comparison between ammonia and sodium-base sulphite liquor was made with beech. Ammonia base showed a higher decrease of pH of the liquor than sodium base and a greater velocity than the latter at the same pH. Although both bases gave nearly the same qualities of pulps for the same yield, the ammonia-base pulp was slightly superior in its Roe number, lignin, and holocellulose contents, and in mechanical strength, but was somewhat inferior in its color.

KUWABATA, S., Jap. pat. 4801 ('53), (Sept. 26, 1953); *C.A.* 48: 11059 (1954).

Spent liquor containing ammonium sulphite is treated with a suitable amount of sulphuric acid to give sulphurous acid and ammonium sulphate. The product is heated at 120° to vaporize sulphur dioxide and condensed to give sulphurous acid; the residue is heated with calcium hydroxide to give ammonia which reacts with sulphurous acid to give ammonium sulphite.

JENNESS, L. C., *Tappi* 37, No. 8: 137A–139A (1954); *C.A.* 48: 12405 (1954).

About 75% of the available ammonia in waste ammonia-base sulphite liquor could be recovered by evaporating this liquor together with waste kraft liquor, with consequent condensation of the ammonium hydroxide. Foaming but no scaling resulted during the evaporation. The mercaptans in the recovered ammonium hydroxide had no harmful effect on the bleachability or strength properties of the resulting pulps.

MARKHAM, A. E., and MCCARTHY, J. L., *Tappi* 37: 355–363 (1954); *cf. C.A.* 48: 361; *C.A.* 48: 12405 (1954).

A study was made of the absorption of ammonia ion from ammonium sulphite spent liquor by the ion-exchange resin Dowex 50 and of the stripping of these ions from Dowex 50 by sulphurous acid. Eleven cycles of exchange were carried out batchwise in a fully described (and illustrated) apparatus consisting of six fixed bed columns. Conditions of operation, analytical data, and material balances for the various cycles are given. Under the conditions used 60 to 65% ammonia ion was recovered. Twelve references.

HULL, W. Q., SMITH, B.C., HULL, J. H., and HOLZER, W. F., *Ind. Eng. Chem.* 46: 1546–1557 (1954).

The ammonia-base sulphite process was in use in 10 American mills in 1953. An ammonium bisulphite solution with

H. BORDEN MARSHALL and ANN MACDONALD, Ontario Research Foundation, Toronto, Ont.

excess sulphurous acid (prepared from ammonia, water, and sulphur dioxide in a countercurrent absorbing tower) is heated 6 to 12 hr. with wood chips at temperatures up to 275° under 80 to 85 lb. pressure. The ammonium ligninsulphonate, in the spent liquor can be concentrated readily and, in this form, or in spray-dried powder, is suitable for use in adhesives, as an emulsifying agent, soil additive, phenolic extender, dispersant, sequestrant, wind-erosion preventative, and tanning agent. It also burns readily. Pulp from the process is handled normally. The cooking liquor penetrates into the wood more rapidly, thus giving a fast cooking cycle and more uniform pulp than that obtained with calcium-base liquor.

Anon. *Chem. Week* 74, No. 24: 64 (1954); *B.I.P.C.* 24: 924 (1954).

Orzan A (dried ammonia-base sulphite liquor, sold by Crown Zellerbach Corp. on a development basis for about $65 per ton f.o.b. Lebanon, Ore.) is a coffee-colored, granular solid which is dissolved in water before application from a spray truck. Spread thinly over loose soil or sand, it binds the particles into a crust which lasts about 6 weeks under normal conditions. Its soil-stabilization characteristics are studied for combating wind erosion from farmland, binding sand on irrigation-canal banks or dunes surrounding farmland, and similar agricultural applications. Three illustrations.

Felicetta, V. F., Markham, A. E., and McCarthy, J. L., *Tappi* 37, No. 10: 431–436 (1954); *cf. B.I.P.C.* 25: 55; *B I.P.C.* 25: 228 (1954).

The equilibrium distribution of ammonium and hydrogen ions between cation-exchange resins and spent sulphite liquor or sulphurous acid solutions has been determined as a basis for consideration of processes for recovery of ammonia from spent sulphite liquor by absorption on a cation-exchange resin, followed by stripping with a solution of sulphurous or some other acid under various conditions. The results are correlated satisfactorily by the treatment of Bauman and Eichhorn (*cf. J. Am. Chem. Soc.* 69: 2830–2836 (1947)) using an ammonium-hydrogen ion selectivity coefficient of about 1.2 when the ion fraction of conversion to ammonium resin is not above about 0.7. Some data for calcium-hydrogen ion exchange are also reported. In general, it appears probable that the equilibrium distributions for the sodium-hydrogen, and for certain other ion-exchange processes can be estimated with moderately good accuracy simply by carrying out calculations using the selectivity coefficients given by Bauman and Eichhorn and others. Three tables, four figures, and 13 references.

## BINDING MATERIALS

Uschmann, C., U. S pat. 2,585,977 (Feb. 19, 1952); *C.A.* 48: 371 (1954).

A method is given for the preparation of binding materials from spent sulphite liquor. Spent sulphite liquor, 100 lb., is boiled at atmospheric pressure for 15 min. during which 5 lb. NaOH is added. Boiling is then continued for 5 min. To the alkalized and concentrated spent sulphite liquor, 5 lb. furfural is added and boiling is continued with agitation for 5 min. $C_6H_5OH$ (5 lb.) is then added, and boiling continued for 5 min. with agitation. The liquor not treated with $C_6H_5OH$ is used as a binder for low-density wood-fiber products and that after $C_6H_5OH$ treatment as a water-resistant binder for hardboard.

Institut International Financier, Swiss pat. 289,696 (July 1, 1953); *C.A.* 48: 6123 (1954).

Materials containing cellulose and lignin are treated with sulphurous acid or its salts, and the resulting solution is treated with a quantity of alkali hydroxide sufficient to insure that the lignin is completely precipitated and is in such a state that it is fusible in boiling water, but insufficient to break down the lignin. The alkaline solution of the sulphonated lignin is treated with a quantity of sulphurous acid such that, after separation of the precipitated lignin resin, addition of sulphuric acid precipitates no additional resinous material. The resin thus obtained is compounded with other resins, such as phenol-formaldehyde resins, and is used as a laminating agent, e.g., in plywood.

Frokjaer-Jensen, A., and Andreasen, A.H.M., U. S. pat. 2,670,298 (Feb. 23, 1954); *C.A.* 48: 9648 (1954).

Clay is mixed with spent sulphite liquor and fired to give a cellular material of low density and high crushing strength for use as insulating material in walls and floors and also for incorporation in concrete. Thus, clay containing 40% $H_2O$ was mixed with sulphite lye containing 40% $H_2O$ in a ratio of 1% sulphite lye to 99% clay both calculated on a dry basis. Water was added to the mixture in an amount equal to the sulphite lye, and the paste was pug-milled. The material was sliced and fired in a rotary kiln at 1100 to 1125° to give a cellular product with a unit weight of 480 lb. per cu. yd. as compared with an untreated clay weighing 1100 lb. per cu. yd. The product had high-crushing strength. Similarly, additions of 0.125, 0.5, 4, and 8% sulphate lye gave cellular products having unit weights of 900, 700, 590, and 750 lb. per cu. yd. A slate was crushed into 12-mm. pieces and moistened with a saturated solution of sulphite lye containing 10% dry substance, then burned in a rotary kiln at 1225° to give a product having a unit weight of 620 lb. per cu. yd.

Seipioni, A., *Atti ist. veneto sci., lettere ed arti, Classi sci. mat. e nat.* 111: 109–117 (1952–53); *cf. C.A.* 48: 3683; *C.A.* 48: 9745 (1954).

The properties of the resins obtained by the condensation of phenol, formaldehyde, and lignin obtainable from alkaline liquors were compared with those resulting from the condensation with lignin recovered from the sulphite liquors. The desulphonated lignins were obtained by alkaline hydrolysis by autoclaving at 180° for 2 hr. with 2 and 10% NaOH and 4% CaO. This gave products not varying greatly in —OMe, —OH, —COOH, and S content except the case where 2% NaOH was used which gave a lignin containing three times as much sulphur as the other two. The alkaline lignin was prepared by cooking beechwood in 6% NaOH for 3 hr. at 160°. The source of desulphonated lignins was beech spent sulphite liquors. The resins were prepared by dissolving 50 grams of lignin in 50 grams of phenol and adding 50 ml. of 30% $CH_2O$. Oxalic acid was the catalyst. The mixture was boiled and stirred for 2 hr., and in the end the water was distilled *in vacuo* and the final temperature brought to 120 to 125°. For comparison study, resin powders were prepared by mixing resin 40, flour 60, naphthalene 5, hexamethylenetetramine 5, $Ca(OH)_2$ 2 , and stearin 1 part. The condensation with desulphonated lignins was faster and required less catalyst, and the resin powder obtained thereby was superior to that obtained from the alkaline lignin in its behavior under the press. There was greater fluidity, better separation from the press, and more neatness. Also, the resin powder obtained from desulphonated lignins when hardened showed initially a greater breaking load but a slower hardening rate because of its greater thermoplasticity, and finally reached slightly inferior breaking loads. There were no differences during condensation, pressing, and hardening among the resins obtained from the various desulphonated lignins.

Anon. *Chem. Week* 74, No. 22: 56, 58, 60 (1954); *B.I.P.C.* 24: 834 (1954).

Reference is made to a new company which is distributing concentrated spent sulphite liquor as a roadbinder to licensed dealers in the southern part of Wisconsin at distances of 130 to 190 miles from the mill. The distributors will then dilute and apply the liquor to roads. The use of undiluted liquor

as roadbinder is confined to an economical 100-mile radius from the mill, and most of it is sold within 50 miles. Two illustrations.

Müller, H. F., U. S. pat. 2,683,706 (July 13, 1954); *B.I.P.C.* 25: 66 (1954).

The process of preparing fusible lignin resins (from wood-hydrolysis lignin or spent sulphite liquor) suitable for incorporation in molding compositions involves treating the ligneous material with sodium hydroxide in aqueous solution, drying, redissolving the residue in water, precipitating the lignin by adding mineral acid, and then drying the lignin product.

## CHEMICALS

### *Vanillin*

Monsanto Chemical Co. Brit. pat. 695,301 (Aug. 5, 1953); *C.A.* 48: 1001 (1954).

Vanillin is made by oxidation of alkalized concentrated spent sulphite liquor or other lignin-containing materials in the presence of copper or certain copper compounds while heating under pressure. The process is improved by continuously supplying to the autoclave all of the oxygen necessary for the oxidizing reaction, while the spent sulphite liquor is at the reaction temperature. This is accomplished by passing in a mixed gas in the form of fine bubbles containing air diluted with inert gases. The mixed gas has an oxygen partial pressure of less than 6.6 lb. p.s.i. Yields of vanillin equal to or greater than 10.1% based on the weight of spent sulphite liquor solids are obtained.

Lagally, P., Ger. pat. 821,205 (Nov. 15, 1951); *C.A.* 48: 1681 (1954).

Crude sodium vanillin solution obtained by alkaline pressure hydrolysis of spent sulphite liquor in the presence of an oxidizing agent is saturated with carbon dioxide, the by-products are removed by extraction with $C_6H_6$, and the residue is neutralized with mineral acid and re-extracted to give vanillin. Concentrated fermented sprucewood spent sulphite liquor of 28° Baumé 200 (lignin content 60 grams) is mixed with 44% volume per cent commercial aqueous NaOH 250 and $H_2O$ 250 ml. The reaction product of $Me_2NC_6H_5$ 130 and 30% aqueous $H_2O_2$ 250 ml. is added and the mixture heated for 3 hr. at 170 to 190° in a closed vessel. The crude sodium vanillin-containing reaction mixture is steam-distilled to remove 125 ml. $Me_2NC_6H_5$ and the residue is saturated with carbon dioxide to a pH of 9. The 1st extraction with $C_6H_6$ gives a resinous residue practically free of vanillin. The aqueous solution is acidified with 50 ml. 37% HCl (pH 7). The second extraction with $C_6H_6$ gives 5.0 grams resin-free crude vanillin which yields 3.5 grams high purity vanillin on further purification. The yield is 6% based on the weight of lignin.

Salvo Chemical Corp., Brit. pat. 703,418 (Feb. 3, 1954); *C.A.* 48: 6698 (1954).

A process for the production of vanillin from spent sulphite liquor. See U. S. pat. 2,598,311 (*C.A.* 46: 7770).

Kaneko, K., and Mitobe, T., Jap. pat. 4331('53), (Sept. 2, 1953); *C.A.* 48: 9692 (1954).

Spent liquor, from the sulphate or soda process, is dropped through the top of a tower filled with porcelain grains. Butyl alcohol is fed in countercurrently through the bottom. The butyl alcohol on top is collected and distilled. The residue containing 4,3-NaO(MeO)$C_6H_3$CHO is treated with sulphuric acid. Free vanillin is obtained by solvent extraction. The butyl alcohol in the down flow is recovered, combined with that recovered from the top flow, and recycled.

Pearl, I. A., and Beyer, D. L., *J. Am. Chem. Soc.* 76: 2224–2226 (1954); *cf. C.A.* 46, 11050; *C.A.* 48: 11052 (1954).

A study was made of the cupric oxide oxidation of lignin model substances. The reaction of vanillin, 5-propenylvanillin, and 5-allylvanillin with cuprous oxide and alkali under the conditions of ligninsulphonate oxidation yielded only monoguaiacyl compounds. The reaction of the bis-vanillyl compounds, vanillil, vanilloin, deoxyvanilloin, hydrovanilloin, and bivanillyl under the same conditions yielded vanillil, vanillovanillone, vanillin, vanillic acid, dehydrodivanillin and others. Thus the occurrence of many compounds in ligninsulphonate cuprous oxide reaction mixtures can be accounted for on the basis of a bis-vanillyl structure in the lignin molecule.

Leopold, B., *Svensk Papperstidn.* 55, 816–819 (1952); *cf. C.A.* 47: 10500; *C.A.* 48: 12402 (1954).

Previous investigations on the influence of methylation of wood on the yield of vanillin, obtained on subsequent oxidation with $PhNO_2$ and alkali, were extended to the following: Norway sprucewood (MeO 5.0%), Douglas-firwood, digested by termites (MeO 10.3%; *cf. C.A.* 48: 11780), low-sulphonated lignin (S 4.3, MeO 12.2%, *cf. C.A.* 39: 2196), ligninsulphonic acid (S 5.8, MeO 11.2%), precipitated with "BIS" bis-(dimethylaminophenyl)-methane and the wood of *Betula alba* (MeO 7.1%). All materials were methylated with $CH_2N_2$, and $Me_2SO_4$; Norway sprucewood and low-sulphonated lignin were also methylated with anhydrous MeOH and HCl, and oxidized under standardized conditions. Control experiments were made with alkali and HCl in the absence of methylating agents. Methylations with $CH_2N_2$ and with MeOH–HCl caused moderate decreases in yields of vanillin, in the latter case probably because of the action of hydrochloric acid. With $Me_2SO_4$, fair yields were obtained from low-sulphonated lignin and ligninsulphonic acid and very low yields from Norway sprucewood, Douglas-firwood, and the wood of *Betula alba* (the wood of *Betula alba* giving vanillin and syringaldehyde). Sulphonation of wood prior to methylation counteracted the decrease in yield but pretreatment with acid had no effect. Sulphonation after methylation increased the yield from 18 to 39%. The variations in yield may depend on a prevention of the alkaline splitting of phenolic ether linkages in lignin, caused by the methylation of PhCH(OH) and phenolic OH groups. This view is supported by evidence from oxidation experiments with vanillyl methyl ether, tetrahydroacetoguaiacylacetoguaiacone trimethyl ether, and hexahydrobis (acetoguaiacyl) acetoguaiacone tetramethyl ether. The yield of vanillin from vanillyl methyl ether was 63% of theory and from tetrahydroacetoguaiacylacetoguaiacone trimethyl ether and hexahydrobis(acetoguaiacyl) acetoguaiacone tetramethyl ether was almost nil. On heating tetrahydroacetoguaiacylacetoguaiacone trimethyl ether with alkali alone 90% remained undissolved as compared with 7% for the parent substance Me[O(MeO)$C_6H_3$CH(OH)$CH_2$]$_2$H. Vanillyl methyl ether was prepared as a colorless oil $b_{1.5}$ 112–15°, $n_D^{22}$ 1.5407 in 55% yield by passing dry HCl into a solution of 1 gram vanillyl alcohol in 15 ml. anhydrous MeOH for 10 min., neutralizing with solid $NaHCO_3$, extracting with $Et_2O$, and distilling the extracted material *in vacuo*. Tetrahydroacetoguaiacylacetoguaiacone trimethyl ether and hexahydrobis(acetoguaiacyl)acetoguaiacone tetramethyl ether were formed similarly but without final distillation, the crude yields being 69 and 78% respectively, from the parent substance Me[O(MeO)$C_6H_3$CH(OH)$CH_2$]$_2$H and hexahydrobis-(acetoguaiacyl)acetoguaiacone methyl ether (*cf. C.A.* 44: 7338). Me[O(MeO)$C_6H_3$CH(OH)$CH_2$]$_2$H, first reported as an amorphous solid, was finally crystallized, m. 127 to 128° (from petroleum ether). The crude tetrahydroacetoguaiacyl-acetoguaiacone trimethyl ether and hexahydrobis(acetoguaiacyl)acetoguaiacone tetramethyl ether were easily sulphonated to the corresponding sulphonic acids and had ultraviolet absorption spectra very similar to those of Me-[O(MeO)$C_6H_3$CH(OH)$CH_2$]$_2$H and hexahydrobis(acetoguaiacyl)acetoguaiacone methyl ether. Treatment of Me[O-(MeO)$C_6H_3$CH(OH)$CH_2$]$_2$H with HCl in $CHCl_3$ gave a product with a distorted ultra violet spectrum, poorly soluble

in sulphite cooking liquor but yielding considerably more vanillin than tetrahydroacetoguaiacylacetoguaiacone trimethyl ether; this excludes the possibility that the crude tetrahydroacetoguaiacylacetoguaiacone trimethyl ether and hexahydrobis(acetoguaiacyl)acetoguaiacone tetramethyl ether were contaminated with significant amounts of condensation products.

Marshall, H. B., and Sankey, C. A., U. S. pat. 2,686,120 (Aug. 10, 1954); *B.I.P.C.* 25: 169 (1954).

Wood chips or other cellulosic materials are pulped under alkaline conditions in the presence of a finely divided gas containing oxygen at 150 to 200°C. The oxidation products of lignin produced during the pulping process include vanillin and, in one example, the yield of this compound amounted to 15% of the lignin in the dry wood. This is similar to Canadian pat. 470,916 (Jan. 16 1951); *cf B I.P.C.* 21: 446. Two figures.

Anon. *Chem. Eng.* 61, No. 10: 114–16 (1954); *B.I.P.C.* 25: 230 (1954).

The novel process of Ontario Paper Co. for making vanillin from the effluent of the company's sulphite alcohol plant at Thorold, Ont., is described. The process is covered by U. S. pat. 2,576,752–4, granted to Fisher and co-workers Nov. 27, 1951 (*cf. B.I.P.C.* 22: 386), and is based on the oxidation of the lignin-containing liquor in the presence of lime. In addition to purified vanillin (half of the output going to U. S. consumers), Lioxin (trade name for an intermediate product containing 97% vanillin and other components) is being prepared. The odor and taste of this compound are distinctly different from vanillin, so that it cannot normally be substituted for the latter; it is being developed as an intermediate for new uses where the more expensive vanillin would be uneconomical. Three illustrations.

Bryan, C. C., U. S. pat. 2,692,291 (Oct. 19, 1954); *B.I.P.C.* 25: 340 (1954).

Controlled oxidation of concentrated spent sulphite liquor to vanillin is claimed to result in improved yields when the partial pressure of the oxygen admitted to the alkaline reaction mixture is regulated within the close limits which depend on the stage of the reaction. Steam, nitrogen, or a similar inert gas is employed to dilute the air admitted to the mixture for improved process control. Five figures.

***Other Phenolic Compounds***

Monnberg, R., Ora, A., and Lehmuskoski, U., *Paperi ja Puu* 35: 8–12 (1953); *C.A.* 48: 362 (1954). See also *Svensk Papperstidn.* 56: 46–49 (1953).

The isolation of pentamethyl phenol and duroquinone from spent sulphite liquor is described. The phenolic compound previously isolated from spent sulphite liquor (*C.A.* 45: 2203) has been definitely identified as $Me_5C_6OH$. Significant amounts are obtained only when the lignin is precipitated from the spent liquor with lime at temperatures above 100° and then treated with dilute hydrochloric acid. Lignin then reacts with MeOH and CaO at 325 to 350° to produce over 19% of crude $Me_5C_6OH$. It is important to distil the product from the reaction mixture without attempting to remove the calcium oxide. Treatment of $Me_5C_6OH$ with chromic acid gave duroquinone; duroquinone, $Me_5C_6OH$, and other polymethyl phenols formed could be used as cheap raw materials in organic synthesis.

Swidinsky, J., McMillan, F. H., and King, J. A., *J. Am. Chem. Soc.* 76, No. 4: 1148–1151 (1954); *B.I.P.C.* 24: 663 (1954).

Ten amides have been prepared by the reaction of methylated *l*-conidendrin (obtained from the spent sulphite liquor of western hemlock pulping) with a variety of amines, and three of these amides have been reduced to the corresponding amino derivatives of conidendrin by lithium aluminum hydride. It has been observed that the lactone linkage in the dehydrogenated methylated conidendrin is very stable and nonreactive. One table and 32 footnotes.

## EMULSIFYING AND DISPERSING AGENTS

A. Holtman & Co., Ger. pat. 896,645 (Nov. 12, 1953); *C.A.* 48: 4234 (1954).

A method is described for the production of detergents, dispersing and wetting agents. Spent sulphite liquor is condensed with alkyl, alkylaryl, aryl, aralkyl, or acyl (particularly $SO_3H$-containing) organic compounds, preferably in form of their reactive halo derivatives. The condensation products are possibly brightened by treatment with bleaching agents. For example, 80 kg. alkylsulphonyl chloride (obtained by treating kogasin with a $ClSO_2$ mixture) is heated with 200 kg. spent sulphite liquor (sodium ligninsulphonate content of 50%) at 50 to 60° in the presence of alkaline metal hydroxides. The reaction mixture is diluted with water, and the unsaponifiable constituents are removed. The residue is a slightly viscous liquid which may be treated stepwise with 2 to 3% $H_2O_2$ while heating to give a yellow-brown product.

Kleinert, T., and Ruck-Floriantschitsch, M., *Das Papier* 8: 13–17 (1954); *C.A.* 48: 5493 (1954).

The volume and stability of foams from various spent liquors were studied. All were shown to be three-phase systems. In two instances the $Et_2O$ extract (and its MeO and S content), the per cent fibers and fiber fragments, the ash and its components were determined. The $Et_2O$ contained about 50% acids and 12 to 15% unsaponifiables. Stable foams always contained surface-active components and appreciable amounts of fibers rich in extractives. From the $Et_2O$ extract of a beechwood spent liquor was isolated a ligninlike surface-active substance containing 23 to 24% MeO which exerted a marked influence on foaming. The volume increased with the concentration of the liquor. In the acid range, up to about pH 5, especially in spent spruce liquors, the volume was relatively low but increased sharply with increasing pH. In beechwood spent liquor, the maximum volume was obtained when the fiber content was low (up to about 0.5 gram per liter); above this point, the volume decreased. The stability of the beechwood spent liquor was greatly increased when the liquor was aged. In fresh beechwood spent liquor, the maximum stability was reached when the fiber content was 4.4 grams per liter. With an 8-day-old beechwood spent liquor, the maximum was obtained with a fiber content of 2.8 grams per liter and the stability was over four times that of fresh beechwood waste liquor. The highest stability was shown by liquors diluted with 30 to 100 parts $H_2O$. Minimum stability occurred at pH 7, rising very rapidly both in the acid and alkaline ranges. Neither volume nor stability was much affected by temperature changes between 0 and 25°. With increasing rosin size addition to beechwood spent liquor, the volume increased very slightly, whereas stability decreased sharply. The probable mechanism of foam formation is discussed.

Grzymek, J., *Cement-Wapno-Gips* 10, No. 19: 117–24 (1954); *C.A.* 48: 12385 (1954).

The use of new materials, especially byproducts such as spent sulphite liquor (*C.A.* 48: 6669), in the manufacture of cement is discussed. The waste sulphite liquor can be used as a 50% solution or as a powder. In commercial plants good results were obtained when both spent sulphite liquor and blast-furnace slag were added to the Portland clinker before grinding. Then the ground product required 7% less water than Portland cement to obtain the same plasticity for building applications. The spent sulphite liquor did not contain any sugar.

Nomura, J., Jap. pat. 642('54), (Feb. 4, 1954); *C.A.* 48: 14153 (1954).

Spent sulphite liquor (300 l.), containing 19.88% solids, is treated with 10 kg. CaO after alcohol fermentation. The solution is treated for 4 hr. with alternating current at 100 v. and the precipitate filtered. The filtrate is neutralized with sulphuric acid and filtered to give a product containing 32.11% Ca ligninsulphonate.

Jones, R. V., U. S. pat. 2,688,611 (Sept. 7, 1954); *B.I.P.C.* 25: 244 (1954).

Lignin sulphates for use in adhesives, rubber, inks, etc. are prepared by treating lignin with a sulphonating agent such as a metal chlorosulphonate in the presence of an inert diluent such as benzene and of a tertiary amine such as pyridine. The water-soluble residue is precipitated into methanol from which it is separated by filtration, collected, and dried to give the lignin sulphate of the metal used in the sulphonating agent.

## EVAPORATION AND BURNING

Sadler, H., Bellah, F., and Röder, H., *Das Papier* 7: 416–424 (1953); *C.A.* 48: 5494 (1954).

In a series of laboratory experiments, the liquors from spruce sulphite and kraft cooks were recovered quantitatively, and their fuel values determined. Spent sulphate liquors contained far more inorganic matter than did spent sulphite liquors and, under normal cooking conditions, fuel values of spent sulphate liquors were up to 30% lower than those of spent sulphite liquors. Based on oven-dry solids, the following mean fuel values were found: for spent sulphate liquor maximum 3450 kcal. per kg., minimum 3250; for spent sulphite liquor 4370 and 4170 kcal. per kg. However, under very drastic cooking conditions, it was possible to obtain spent sulphate liquor containing more organic matter than that in spent sulphite liquor and under such conditions spent sulphate liquor showed the higher fuel value. In general, the softer the pulp and the lower the pulp yield, the higher was the average fuel value of the dried liquor. The relationship between fuel value, ash content, and percentage of water of a waste liquor was determined and is shown graphically.

Simmons, T., *Pulp Paper Mag. Can.* 55, No. 1: 108–110 (1954); *C.A.* 48: 5494 (1954).

Spent sulphite liquor has been successfully burnt, without other fuel and without ash deposition on the boiler, in a cyclone burner in advance of the boiler furnace.

Lockman, C. J., Swed. pat. 144,001 (Feb. 9, 1954); *C.A.* 48: 8544 (1954).

An apparatus for the recovery of heat and sulphur dioxide from spent sulphite liquor.

Scholander, A., *Svensk Papperstidn.* 55, 620–621 (1952); *C.A.* 48: 9059 (1954).

The sulphur balance in the evaporation of spent sulphite liquor was studied at four different stations. Sulphur losses with condensates, steam, and venting gases amounted to 0 to 20% of the total sulphur. The losses increase with increasing temperature of the station and decreasing pH of the liquor.

Mannbro, N., *Svensk Papperstidn.* 55: 665–667 (1952); *cf. C.A.* 45: 9265; *C.A.* 48: 9688 (1954).

In a proposed sulphite process soda melt is dissolved in waste sulphite liquor which has been neutralized by precipitation of all Ca as $CaCO_3$ and $CaSO_3$ and filtered. Sulphide brown liquor is obtained and after removal of solid impurities hydrogen sulphide is expelled with carbon dioxide when soda brown liquor is formed. Sulphur dioxide from burning the hydrogen sulphide is dissolved in this liquor to a proper ratio of sodium sulphite to sodium bicarbonate to give sulphite liquor. The spent sulphite liquor is evaporated and burnt. Several alternatives are suggested to fit the proposed new process to sulphate and sulphite processes, e.g. burning spent sulphite liquor together with black liquor. In laboratory experiments with the proposed new process, with birch and pine, pulps with good properties (breaking length 8800 and 9700 m., bursting strength 59 and 72, and tearing strength 190 and 180 g.-cm. per cm. after 11,500 and 9700 revolutions in the Lampen mill) were obtained in about 70% yields.

Sillen, L. G., and Andersson, T., *Svensk Papperstidn.* 55: 622–631 (1952); *C.A.* 48: 9688 (1954).

The equilibrium between gas and ash are discussed for various conditions in burning concentrated calcium or magnesium spent sulphite liquor with special emphasis on the recovery of sulphur. With the assumptions $p_{CO_2} + p_{CO} = 0.15$, $p_{H_2O} + p_{H_2} = 0.10$, and $p_{H_2S} + {}^1/_2 p_{S_2} + p_{SO_2} + p_{SO_3} = 0.01$ atm. logarithmic diagrams with partial pressures ($-\log p$ vs. $rO = -\log p_{O_2}$) are constructed for 800, 1200, and 1500°K., from the equilibrium constants calculated by Whitney, *et al.* (*C.A.* 46: 255). These *rO* diagrams show which equilibrium need be considered or can be neglected. At temperatures and *rO* ranges when the equilibrium pressure of sulphur dioxide would exceed 0.01 atm. all sulphur will be in the gas phase. Diagrams with $\Delta = 100(p_{O_2} - {}^1/_2 p_{H_2} - {}^1/_2 p_{CO})$, i.e., roughly the oxygen excess or deficiency, versus temperature illustrate the conditions for obtaining sulphur in the gas phase as sulphur dioxide or hydrogen sulphide or in the solid phase as sulphate or sulphide. The least desirable sulphur compound, $CaSO_4$, is easily obtained but sulphur can also be recovered either as sulphur dioxide in the gas or as calcium sulphide in the ash if the rates of attainment of equilibrium and of secondary reactions on cooling ash and gases are favorable. With magnesium one can obtain all sulphur in the gas as sulphur dioxide or hydrogen sulphide under a wide range of conditions. It does not seem possible to obtain magnesium sulphide by combustion.

Goddard, H. O., U.S. pat. 2,676,883 (April 27, 1954); *C.A.* 48: 9692 (1954).

A method and apparatus for concentration of spent sulphite liquor with a minimum amount of steam and with a minimum of scaling are described. Modifications for producing finely divided fuel or starting material for fermentations are also described. Steam for use in the sulphite pulp plant is generated at a higher pressure than that required in the operation of the plant. This high-pressure steam is used to concentrate and dry the waste sulphite liquor to a form useful as fuel and containing approximately 8000 B.t.u. per lb. of dry solids. This fuel may be substituted for pulverized coal. The sugars in the spent sulphite liquor may be converted to alcohol after concentration and sulphur dioxide removal.

Craig, D., Elgee, H., and Russell, J. K., *Pulp Paper Mag. Can.* 55, No. 5: 97–102 (1954); *C.A.* 48: 10340 (1954).

The results of translation from pilot plant studies on the thermal compression evaporation of spent sulphite liquor (*C.A.* 44: 6120) to commercial operation are described. Because of scale formation satisfactory operation is obtained for 20 hr. only. The scale is then removed by operation of the evaporator from the regular feed rate of 65 to 180 gal. per min. of recovered distillate, this occupying 4 hr. between shut-down and start-up. The net evaporation is 14.8 lb. $H_2O$ per lb. steam.

Cederquist, K. N., Swed. pat. 143,765 (Jan. 19, 1954); *C.A.* 48: 10345 (1954).

A method for the recovery of the heat content of the organic substances in spent sulphite liquor is described. The liquors are oxidized at about 200° with air or oxygen under

about 25 atm., preferably in the presence of an oxidation catalyst such as copper, iron, vanadium or one of their derivatives, and also, if desired, an alkali or alkaline earth oxide or carbonate. The heat generated is recovered by blowing out the hot gases. Temperatures up to 300° and pressures up to 200 atm. may be used.

Madej, R., *Przeglad Papier.* 10: 75–76, 85–86 (1954); *C.A.* 48: 11056 (1954).

A review of process conditions and equipment for burning concentrated calcium-base spent sulphite liquor, with particular reference to the results obtained in the sulphite pulp mill at Loddby, Sweden.

Anon. *Pulp and Paper* 28, No. 2: 78,80 (1954); *B.I.P.C.* 24: 546(1954).

The spent liquor evaporation and burning plant of Northern Paper Mills (subsidiary of Marathon Corp.), Green Bay, Wis., is described in a series of eight pictures. The major equipment of the plant is the Conkey flat plate Rosenblad switch system evaporators; two boilers were converted to burn the concentrated liquor, along with powdered coal. Eight illustrations.

Zimmerman, F. J., U. S. pat. 2,665,249 (Jan. 5, 1954); *B.I.P.C.* 24: 687 (1954).

The oxidation of waste effluents such as spent sulphite liquor, kraft liquor, Masonite liquor, sewage, cheese plant whey, or any waste effluent containing organic matter is accomplished by the introduction of a heated oxidizing medium (e.g. compressed air) under pressure of 1500 p.s.i. into a tank or tanks containing the waste material heated to the point (usually between 480 and 625°F.) at which oxidation will take place. In the self-sustaining process, heat recovery from the unit is claimed to be as high as 95% of the theoretical value in the material, thus producing power in excess of that required for the processing. The completely oxidized effluent is drawn off into a flash chamber from which the gases and steam are bled at a pressure of 1500 p.s.i.

Brunes, B., *Svensk Papperstidn.* 57, No. 9: 317–330 (1954); *cf. B.I.P.C.* 22: 284; *B.I.P.C.* 24: 924 (1954).

Continuing his 1951 review, the author discusses recent developments in the recovery, evaporation, and combustion of calcium-base spent sulphite liquor. The collection of calcium-base spent sulphite liquor from the blowpits is finding increased application; tests show that a high yield of dry substance without appreciable dilution of calcium-base spent sulphite liquor may be obtained in this manner. The need for an instrument for measuring and recording the dry substance of calcium-base spent sulphite liquor from each pit is pointed out, and the incrusting problem in a continuously operating displacement system of this type (which results in a liquor with a high calcium sulphate content) is mentioned. Practical experience indicates the suitability of vacuum and counter-pressure evaporators. Methods for combining the evaporation stage and the distillation to alcohol have been developed and are used on a commercial scale; the conventional alcohol plant for fermented calcium-base spent sulphite liquor is replaced by equipment which is more reliable in operation and less space consuming. Evaporation by means of thermocompressors is discussed in some detail; this method will probably assume great importance in the future, particularly in plants with available low-cost electric power. The economics of the different evaporator systems are compared. With regard to the combustion of calcium-base spent sulphite liquor, the Loddby furnace and its operation are discussed, including methods for overcoming the fly-ash problem. A table listing the Swedish installations of this furnace with pertinent data is included. The results of numerous tests indicate that calcium-base spent sulphite liquor can now be burned with a high combustion efficiency without use of additional fuel. Three tables and 21 figures.

Solvberg, K., *Norsk Skogind.* 8, No. 7; 229–235 (1954); *B.I.P.C.* 25: 17 (1954).

The process of scale formation on the heating surfaces and some of the significant factors which influence the amounts of scale deposited during the evaporation of spent sulphite liquor have been investigated. The studies were made in a counterpressure evaporator of the Rosenblad type equipped with channel switching and natural circulation. The liquor was obtained from greaseproof and strong sulphite cooks. In one part of the experiments, an extra heating surface was added to one of the evaporators of the system. The extra heating surface was removable so that the scale deposits could be studied. The results showed that the deposits on the lower part of the heating surface are porous and coarse grained; the principal constituent is calcium sulphate. The higher steam velocities in the upper part of the channel cause an increase in the deposits on the upper sections of the extra heating surface and also gave a smoother surface. Once a certain thickness is reached, the rate of scale formation increases considerably. The author believes that this phenomenon, together with inadequate cleaning in counter pressure evaporators, is the real cause for the sudden drop in capacity which takes place after the evaporator has been in operation for some time. Additional experiments with polished and rough heating surfaces have confirmed this theory. A smooth surface may accelerate the deposition mechanism, but it also prevents the adherence of the deposits to such a surface. In full-scale experiments, it was found that the simplest way of keeping the evaporator free from calcium sulphate is the use of a high-solids concentration in the liquor to be evaporated. The cleaning of the plant is most effective when the rate of evaporation is low; at normal (and higher) capacity of the plant an increase in the accumulation of calcium sulphate results. The duration of the channel-switching periods seems to be of less importance, as long as the output is kept below normal. The present experiments were carried out without preheaters. Five tables and 10 figures.

Holgersson, S., Can. pat. 504,342 (July 13, 1954); *B.I.P.C.* 25: 64 (1954).

The device for the evaporation of spent liquor involves the use of large quantities of air forced by fans through a porous mat supplied with liquor from an overhead spray system. This mat is made from wood shavings or similar material and varies from 0.1 to 1 m. in thickness with a thickness of 0.5 m. usually desirable. Waste liquor from the pulp mill is pumped to a cistern below the mat and repumped from this cistern to the spray nozzles mounted over the mat. The cistern provides storage for the liquor produced during that period of the year when outside temperatures are too low to make use of the evaporation system. Five figures.

Söderlund, G. K., Lindberg, S. G., and Simmons, T. M. G., Can. pat. 504,179 (July 6, 1954); *B.I.P.C.* 25: 77 (1954).

A separated cyclone combustion chamber for spent sulphite liquor is provided to prevent deposition of sticky particles on the cooled walls of the furnace. The liquid fuel and air for combustion are introduced into this chamber to produce a vortex of burning particles extending the length of the chamber, with the ash particles crushed by contact with the walls to destroy the hollow character of these particles. Two figures.

Söderlund, G. K., Lindberg, S. G., and Simmons, T. M. G., U. S. pat. 2,678,615 (May 18, 1954); *B.I.P.C.* 25: 339 (1954).

A method for burning sticky, water-containing liquid fuel (concentrated spent sulphite liquor) is described. This process is identical to Canadian pat. 504,179 (July 6, 1954).

Schoedler, K., *Wochbl. Papierfabrik.* 81: 470, 472, 474, 476 (1953); *cf. C.A.* 47: 6597; *C.A.* 48: 361 (1954).

A continuation of Schoedler's previous report on the improved utilization of spent sulphite liquors from coniferous and beechwood by bacterial fermentation to acetone, butanol, and ethanol. It deals mainly with the economic aspects of the use of acetone, butyl alcohol, and butyl acetate as solvents in the lacquer, artificial silk, and plastics industries (production figures for which are given). Butyl derivatives as plasticizers are discussed very briefly.

Mariani, E., and Torraca, G., *Ind. carta* (Milan) 7: 47–51 (1953); *C.A.* 48: 2366 (1954).

Sugars were determined in sulphite liquor by the use of paper chromatograms, using Whatman no. 1 filter paper, with 0.05 ml. solution and BuOH-AcOH-$H_2O$ (4:1:5 by volume) or phenol-$NH_3$ as solvents, at 18 to 20°, during 65 to 72 hr., with 3% p-anisidine-HCl in BuOH or 3% resorcinol in EtOH containing 5% concentrated HCl as developers. Before applying the latter, the solvent was evaporated and the sprayed strips were heated 1.5 to 2 min. at 120° or 3 min. at 80°, respectively, for the two reagents. First, the sulphite liquor was passed through cation and anion-exchange resins and decolorized, if necessary, by Duolite S 30. With BuOH and solvent and p-anisidine-HCl, glucose, xylose, and galactose were clearly detected (brown, red, and brown spots, respectively); mannose was better separated from arabinose with PhOH solvent and p-anisidine-HCl. Ketoses were detected with resorcinol (red spot). The sugars present in sulphite liquor after various cooking periods were investigated. In 2-hr. liquors substantially no sugars were present. Sugars began to appear after 4 hr.; xylose after 6 hr. and increased thereafter. Glucose began to appear in increasing amounts after the 8 hr.; galactose appeared before glucose. Arabinose began at the 4th hr. and was maximum at the 6th, decreasing thereafter. Mannose accompanied arabinose but increased always. Fructose appeared at the 10 to 14th hr. Two other (yellow) spots, appearing in the BuOH and p-anisidine-HCl test with final liquors, could not be ascribed to any sugar, but investigation is going on. Estimation of the spot intensities gave the following relative amounts in the final liquor: glucose and galactose 1, arabinose 7, xylose 9, mannose 10, fructose less than 1.

Jensen, W., *Paper and Timber* (Finland) 32B: 329–332 (1950); *C.A.* 48: 4173 (1954).

A constant-boiling fraction (b.p. 250°/atmospheric pressure) was isolated from fusel oil obtained in the production of alcohol from spent sulphite liquor by distillation by using a spinning band column. It was shown to be an azeotropic mixture containing 4-hydroxy-3-methoxy-1-propyl-benzene as one component.

Joseph, H. G., *Chemistry in Can.* 5, No. 11: 23–27 (1953); *C.A.* 48: 5493 (1954).

An outline of the process of manufacturing industrial alcohol from spent sulphite liquor at Thorold, with special reference to some improvements in refining the alcohol and other fermentation by-products.

Smirnov, V. A., and Bondarenko, A. N., *Trudy Leningrad. Tekhnol Inst. Pishchevoi Prom.* 1(IX): 77–90 (1949); *C.A.* 48: 6119 (1954).

One cubic meter of sulphite liquor yields 5.86 l. of absolute EtOH. The loss of EtOH during the mash rectification process is about 5%. The normal steam consumption per dl. alcohol is about 260 kg.

Yamaguchi, T., Toda, H., and Hamada, C., *J. Japan. Tech. Assoc. Pulp & Paper Ind.* 7, No. 4: 12–18 (1953); *C.A.* 48: 7256 (1954).

The manufacture of fodder yeast from spent sulphite liquor was studied using *Mysotorula japonica* and *Candida tropicalis.* When multiplication was most desirable, the yields of yeast were about 50% of the sugar consumed and the B.O.D. was reduced to about 50% of the original value. There is a large amount of sugar in the spent liquor of precooked kraft pulp, but it was hardly consumed by these yeasts as it consisted mostly of pentose.

Samuelson, O., Gabrielson, G., and Hartler, N., *Svensk Papperstidn,* 55: 613–619 (1952); *cf. C.A.* 41: 2894; *C.A.* 48: 9060 (1954).

Formulas have been derived for calculation of the alcohol recovery from spent sulphite liquor in evaporation steps of three different kinds. The theoretical recoveries after one, two, and three steps are given. Starting from Margule's formula and the equation of Gibbs-Duhem, equations are derived which are useful for the calculation of complete equilibrium curves for binary systems at subatmospheric pressures when many but uncertain experimental values are available. Two full-scale evaporation plants were investigated. The results agreed with theoretical calculations. The recovery of condensate from two evaporation steps gave an alcohol yield of 91%, from three steps 98% or more.

Jensen, W., and Rinne, P., *Paperi ja Puu* 34B: 137–139 (1952); *C.A.* 48: 9613 (1954).

Fusel oil from 15 Finnish sulphite mills was analyzed by distilling in a spinning band column. Distillation curves are given, and in one case the chemical constitution of each fraction was checked after redistillation by determining specific gravity, elementary analysis, molecular weight, OH number, and optical activity.

Nomura, J., Ogura, R., and Kawamoto, K., *J. Fermentation Assoc.* (Japan), 10: 302–305 (1952); *C.A.* 48: 13218 (1954).

The Bertrand method (*cf. C.A.* 1: 1630), the Fehling-Lehmann-Schoorl method, and a modified Lane method (*cf. C.A.* 17: 1400) for determining sugars in spent sulphite liquor were compared. The last method, in which a definite amount of the boiling Fehling solution is titrated with sugar solution with methylene blue as the indicator in a specially devised apparatus, was most applicable to spent sulphite liquor freed from sulphur dioxide (but containing lignin).

Schmidt, E., *Unasylva* 7, No. 4: 152–154 (1953); *B.I.P.C.* 24: 928 (1954).

The method used by the chemical pulp industry in Germany today for the continuous growing of *Torula utilis* according to the Waldhof process is described. The spent sulphite liquor principally used in yeast production is spent beech liquor; on the spent liquor of each short ton of beech pulp produced, 200 to 240 lb. of yeast can be grown. The food value of the yeast and its use in feeding livestock are discussed. Three tables.

Food and Agriculture Organization of the United Nations, Technical Panel on Wood Chemistry. Sixth meeting, Stockholm, 1953. Rome, The Organization, 1954, 169 pp.; *B.I.P.C.* 25: 228 (1954).

At the Sixth meeting of the Food and Agricultural Organization of the United Nations, the Technical Panel on Wood Chemistry presented the following papers, listed by authors and titles, on spent sulphite liquor and yeast: Heijkenskjöld, G. Bakers' yeast—1 table, pp. 83–88; Wiley, Averill J., Holderby, J. M., and Fries, Karl W. Food and feed yeast in the U.S.A.—two tables, five figures, and six references, pp. 89–100; Schmidt, Erwin. The production and utilization of food and feed yeast in Germany—three tables, pp. 101–109; Martin, J. B. Research on waste sulphite liquor in agricultural uses—five references, pp. 121–124; and Burström, Hans. Waste sulphite liquor as a fertilizer in Sweden—four tables

and one illustration, pp. 125–129 + one plate. All papers were presented in English.

Ekelund, S.F.A., Can. pat. 505,549 (Sept. 7, 1954); *B.I.P.C.* 25: 255 (1954).

Degassed neutralized spent sulphite liquor in which the pH has been adjusted between 4 and 7 is treated with a certain quantity of yeast to sorb the sugar from the liquor. The yeast is separated from the liquor by filtration, centrifugation, etc. and placed in a nutrient salt solution where it is allowed to ferment; the yeast is then removed from the salt solution which may be re-used until the concentration of ethyl alcohol reaches 15 to 22% by volume. This is identical with U. S. pat. 2,525,214 (Oct. 10, 1950); *cf. B.I.P.C.* 21: 220–221.

Fortress, F., and White, B. B., U.S. pat. 2,689,817 (Sept. 21, 1954); *B.I.P.C.* 25: 255 (1954).

Spent liquors, especially spent sulphite liquors, are steam-stripped of free sulphur dioxide, concentrated to 20% solids, and adjusted to a pH of 6.5 to 7.5 prior to fermentation with bacteria of the genus *Propionibacterium* to produce propionic acid. Other sugars, growth factors, and nitrogen sources may be added to the liquor to increase the yield. The propionic and other acids may be recovered by steam distillation or solvent extraction and the bacteria removed from the fermented spent liquor by filtration.

## FERTILIZERS

Faldner, J., *Wochbl. Papierfabrik.* 82: 111–113 (1954); *C.A.* 48: 6063 (1954).

A pretreated, diluted, neutral spent sulphite liquor from a straw cook, when thoroughly incorporated into an unproductive soil, apparently hastened wheat germination and in no way interfered with its growth. No general conclusions can be drawn from these laboratory experiments.

## FUNDAMENTAL INVESTIGATIONS

Loomis, T. A., and Beyer, R. E., *J. Pharmacol. Exptl. Therap.* 109: 21–25 (1953); *C.A.* 48: 275 (1954).

The heparinlike anticoagulant action of sulphonated lignins from commercial spent sulphite liquor was investigated. Spent sulphite liquor was fractioned by a method similar to that of Markham, *et al.* (*C.A.* 44: 325) and a series of sulphonated lignins was obtained with apparent molecular weights of 20,000 to 310,000. All the fractions showed anticoagulant activity in dogs. They produced transient toxic symptoms, but there was no evident delayed toxicity. All the dogs recovered.

Hunter, R. E., Tracy, J., Cutts, R., Young, R. E., Olin, J., and McCarthy, J. L., *Tappi* 36: 493–497 (1953); *cf. C.A.* 45: 4447; *C.A.* 48: 361 (1954).

The density, viscosity, specific heat, thermal conductivity, and Prandtl number versus concentration and temperature of spent sulphite liquor is reported at various concentrations and temperatures. These properties have been collected from the literature or determined experimentally at various temperatures and concentrations of solids. Best average values of these properties and of Prandtl numbers are proposed and recommended for use in engineering design calculations. Some examples are given to show applications of the data to design of fluid flow and heat-transfer equipment. Twenty-five references.

Neumann, F., *Das Papier* 7: 388–391 (1953); *C.A.* 48: 362 (1954).

Methods are outlined for the rapid determination of inorganic components in spent sulphite liquor by rapid oxidation with hydrogen peroxide. In the determination of nitrogen, 50 to 100 ml. spent sulphite liquor is mixed with 30% $H_2O_2$ (10 ml. per gram of spent sulphite liquor solids) and then added dropwise to a boiling mixture of 10 ml. $H_2SO_4$, 3 grams $K_2SO_4$, and 0.3 gram $Hg_2SO_4$ in a Kjeldahl flask. The mixture is boiled 15 min., made alkaline, and $NH_4OH$ determined in the usual way. By the addition of not more than 1 to 2 drops $HClO_4$, the oxidation is accelerated. For the determination of potassium, the Ca ions in the spent liquor are removed with $(CO_2NH_4)_2$, and the filtered solution is mixed with $H_2O_2$ and added slowly to 3 to 5 ml. boiling $H_2SO_4$. Addition of $HClO_4$ hastens the oxidation. The colorless solution is evaporated in a platinum dish, heated red hot, taken up in 10% HCl, evaporated, and dissolved in 15 to 20 ml. $H_2O$. In the filtered solution, potassium can be determined as $KBPh_4$ (*cf.* Raff and Brotz, *C.A.* 46: 59). When potassium is to be determined as $KClO_4$, the $SO_4$ ions are removed with the $BaCl_2$, 5 ml. $HClO_4$ is added, the mixture evaporated until white fumes of $HClO_4$ appear, and the cold solution treated with 20 ml. alcohol containing 1 ml. $HClO_4$ per 100 ml.

Kitaura, S., Jap. pat. 101 ('53), (Jan. 14, 1953); *C.A.* 48: 371 (1954).

A method for the preparation of an ion exchange resin suitable for the separation of ligninsulphonic acids from spent sulphite liquor is described. A solution of 2 moles HCl and 1 mole aniline is treated with 2 moles 40% HCHO. The product is absorbed by a porous substance (e.g., pumice), filtered, washed with water, immersed in 5% NaOH, washed with water, and dried to give a cation-exchange resin capable of adsorbing 0.1 gram ligninsulphonic acid per gram of resin.

Scipioni, A., *Ann. chim.* (Rome) 43: 273–281 (1953); *cf.* following abstract; *C.A.* 48: 3683 (1954).

The structure of the lignin recovered from the desulphonation of ligninsulphonic acids was investigated. Lignin from desulphonated ligninsulphonic acid has lower MeO and OH contents than the alkali lignin extracted from the same wood. The lower OH content is related to the fact that some OH groups take part in the sulphonation process. In lignin all the OH groups can be methylated and acetylated. Those OH are absent which in alkali lignin can be acetylated but not methylated. Lignin also contains $CO_2H$ groups which alkali lignin does not possess. Ligninsulphonic acid is desulphonated with NaOH and $Ca(OH)_2$ solutions of various concentrations with the following results (type of lignin, lignin recovered, % S, % MeO, % MeO after methylation, % Ac after acetylation, and % $CO_2H$, respectively): alkali, —, —, 19.22, 29.68, 21.95, 0; ligninsulphonic acid, desulphonated with 2% NaOH, 58, 1.6, 14.03, 29.83, 14.17, 0.86; ligninsulphonic acid desulphonated with 10% NaOH, 78, 0.54, 14.80, 31.68, 15.26, 9.40; ligninsulphonic acid desulphonated with 30% NaOH, 63, 0.51, 15.11, 33.42, 17.38, 8.50; ligninsulphonic acid desulphonated with 4% CaO for 2 hr., 52, 0.60, 14.48, 27.42, 13.36, 5.81; and ligninsulphonic acid desulphonated with 4% CaO for 4 hr., 76, 0.55, 13.87, 28.62, 13.70, 7.60.

Scipioni, A., *Chemica e industria* (Milan) 35: 479–483 (1953); *cf.* preceding abstract. *C.A.* 48: 3683 (1954).

The conditions for the desulphonation of ligninsulphonic acid were studied in order to obtain a high yield of products useful in phenol-lignin resin manufacture. Complete desulphonation of ligninsulphonic acid, either in the liquors or isolated, is not obtainable nor is it recommended since degradation conditions are engendered resulting in a loss in yield. The differences in desulphonated lignins obtained under various conditions are included in the table of the preceding abstract. In the condensation with phenol, desulphonated lignins are much more reactive than ligninsulphonic acid. Molding powders containing resins obtained from desulphonated lignins show greater plasticity during calendering operations than resins from ligninsulphonic acid. The similarity of the molding properties of resins obtained

from desulphonated lignins shows the nonutility of excessive desulphonation. It is considered sufficient to remove the $SO_3H$ groups to prevent the formation of molding products having increased hygroscopicity. Nineteen references.

Brauns, F. E., *Das Papier* 7: 446–452 (1953); *C.A.* 48: 5489 (1954).

A lecture in which Brauns shows the difficulties in defining and isolating lignin, the type of bonding of lignin in plant tissues, experiments on colloidal wood with the object of isolating native lignin, and the demethylation of lignin. The system of linkages in lignin building units and lignin sulphonation are discussed. The following analysis of barium ligninsulphonates is described. Barium ligninsulphonates in water are passed slowly through a column containing a suitable cation-exchange resin, the material is carefully eluted, and sulphur is determined in the eluate by Salvesen and Hogan's method (*C.A.* 43: 1182). The column is then turned through 180° and eluted with hydrochloric acid, and barium is removed as barium chloride and determined as barium sulfate. Details are reserved for future publication.

Neumann, F., *Das Papier* 7: 425–426 (1953), *cf. C.A.* 47: 4606; *C.A.* 48: 5493 (1954).

The use of complexon for titration of the bases in sulphite cooking acid and in spent sulphite liquor is discussed. Traces of heavy metals, especially copper, interfere with the titration with complexon. Such interference was prevented by the introduction of about 0.2% KCN into the $NH_4OH$-$NH_4Cl$ buffer solution used in the titration; the mixture maintains its stability for about 2 weeks.

Dymov, K., *Annuaire ecole polytech. etat "Stalin" Sofia* 4: 49–75 (1950–52) (German summary) *C.A.* 48: 6118 (1954).

The use of some organic sulphonic acids and inorganic salts for the preparation of hydrolytic sugar was studied. The hydrolysis of dried wood (conifer) shavings was carried out in seven stages; the temperature of the first stage was 120° and of the last stage, 180°. After every stage, which lasted 30 min., the shavings were washed and treated with fresh catalyst solution; the sugar content of the solution was determined for each stage. The catalytic activity of asphalt extracts, $PhSO_3H$ containing some $H_2SO_4$, spent sulphite liquor, and $Al_2(SO_4)_3$ solution was studied. Asphalt extracts gave maximum and $Al_2(SO_4)_3$ minimum yields of total reducing substances. All catalysts, except spent sulphite liquor, catalyzed also the decomposition of the monosaccharides.

Senju, R., *Bull Chem. Soc. Japan* 26: 143–147 (1953) (in German); *cf. C.A.* 47: 1022; *C.A.* 48: 6689 (1954).

A new method is described for the determination of ligninsulphonic acid in spent sulphite liquor by colloidal titration. The method is based on the precipitation of ligninsulphonic acid with high polymeric aminohydroxyethylchitosan with a degree of polymerization (D.P.) of about 600 and back titration of the excess aminohydroxyethylchitosan with potassium polyvinyl alcohol sulphate. Methods for the preparation of the reagents are described. To 5 ml. spent sulphite liquor diluted 20 to 1, is added 5 to 10 ml. of 0.01 *N* aminohydroxyethylchitosan and the excess back titrated with 0.025 *N* potassium polyvinyl alcohol sulphate (toluidine blue indicator). The ratio of S:N in the precipitate is 1:1. Different samples of spent sulphite liquor all gave precipitates of a ligninsulphonic acid with an equivalent weight of about 380. Consumption of aminohydroxyethylchitosan is dependent on pH during titration, being 1.6 times as much at pH 11 as at pH 3. At the higher pH all the groups able to dissociate ($SO_2$ and OH) are titrated, but only the sulphonic groups at the lower pH. The pH range 2 to 5 is preferred. Waste sulphite liquor, when diluted 1.25:1000 still gives an observable precipitate.

Richter, G. A., and Pancoast, L. H., Jr., *Tappi* 37: 263–272 (1954); *C.A.* 48: 9685 (1954).

In a comprehensive work sulphonation and delignification experiments were carried out with western hemlock, spruce, white birch, southern pine, and Douglas-fir, with sulphurous acid solutions of various pH and of increasing concentrations and over a wide range of temperatures, from room temperature up to 150°. The results are given in numerous graphs and tables. The low temperature sulphonations were carried out over periods of up to 16 months and some of the cooks are followed by short high-temperature cooks. The degree of sulphonation of the lignin in the wood and the amounts of dissolved lignin are determined. At room temperature and with a 10% $SO_2$ solution a slow progressive solution of the lignin takes place, amounting to 62% of the original lignin after 16 months, but the chemically combined sulphur in the residual wood never exceeds 8% based on the lignin. The rate and degree of sulphonation depend on the concentration of the sulphur dioxide solution and the temperature. With increasing replacement of the free sulphur dioxide by combined $SO_2$ ($Na_2SO_3$) the rate of sulphonation decreases. The sulphur content of the ligninsulphonates isolated from the room temperature cooks amounts to about 8 to 10%. Prehydrolysis of the wood with 5 and 25% HCl at 30° or with $H_2O$ or 1% $SO_2$ at elevated temperatures (100 to 150°) deactivates the lignin and interferes both with low temperature sulphonation and with subsequent cooking at an elevated temperature. Pretreatment with strong Cl-$H_2O$ causes a solution of the lignin at a lower degree of sulphonation, probably because of a reduction in the molecular weight of the lignin. Hydrolysis at an elevated temperature of presulphonated wood with acid solutions other than sulphur dioxide causes only a partial delignification except where the lignin has been sulphonated to above 4% S. Similar delignification of wood that has been sulphonated with bisulphite or sulphite at a high temperature is much more difficult. Sulphonation of birch with sulphur dioxide solutions at a low temperature is much slower than that of hemlock, spruce, or Douglas-fir. When hemlock is pretreated with a 10% $SO_2$ solution 2 weeks at 20° and then cooked 2 to 4 hr. at 120° in the same solution a very rapid and complete delignification takes place.

Hartler, N., and Samuelson, O., *Svensk Papperstidn.* 55: 851–862 (1952); *C.A.* 48: 10335 (1954).

A comparison was made of the hydrolytic action of sulphuric acid, high-polymer ligninsulphonic acid, and spent sulphite liquor on cotton and wood pulp at elevated temperatures. The results showed differences between cotton and wood pulp in addition to the particular influences of these acids on the rate of hydrolysis and on viscosity (degree of polymerization (D.P.)), yield, cold and hot alkali solubility, and $CO_2H$ number of the hydrolyzed cellulose. Sulphuric acid and high-polymer ligninsulphonic acid were used in equivalent concentrations as to their ability to invert cane sugar. In order to compensate for the decomposition of high-polymer ligninsulphonic acid the acid solution was circulated through a cooler and an anion exchanger of weakly basic type to remove the low-molecular acids formed, and fresh high-polymer ligninsulphonic acid was added daily. The rate of hydrolysis at 90° was markedly slower and the yield of hydrolyzed cellulose at 100° for a certain viscosity much lower with high-polymer ligninsulphonic acid as compared to sulphuric acid which is explained by a "screening effect", i.e. the high-molecular high-polymer ligninsulphonic acid cannot reach all parts of the fiber accessible to sulphuric acid. For the same reason samples treated with high-polymer ligninsulphonic acid at 90° showed the highest $CO_2H$ number. Experiments with spent sulphite liquor which were performed at 140 and 170° did not include the rate, only the yield and properties of hydrolyzed cellulose from cotton and wood pulp, compared at same viscosity. No difference

in yield was found between sulphuric acid and spent sulphite liquor, nor did the cold or hot alkali solubility differ markedly though 75% of the strong acid anions in waste sulphite liquor were highly polymeric. The main explanation given for this observation is the equalizing influence of the Donnan effect on pH in the fiber and the outer liquor but the more rapid attack of low-molecular acids will also depress the difference between sulphuric acid and spent sulphite liquor. The rate of degradation was at first higher for cotton than for wood pulp and the curves (D.P. versus time) crossed each other but the rates became reverse and a second crossing occurred at D.P. 160 when 26% of cotton and 33% of wood pulp had been removed. The curve for cotton leveled off at a D.P. of about 150, indicating a better resistance in cotton of the crystallites than in wood pulp. The yield of hydrolyzed cellulose from cotton was rather close to 100% down to D.P. 200 and the hydrolysis proceeded with no significant drop in D.P. when 150 was reached, whereas the D.P. of wood pulp decreased invariably with the yield, showing only "semiresistance" at 320. The cold alkali solubility for cotton was less than 5% at D.P. 300 and increased markedly on further reaction, also when D.P. became constant, indicating a change in structure of the hydrocellulose. With wood pulp the cold alkali solubility increased to about 15% at D.P. 400 and then passed a minimum at 300 followed by a striking increase. Compared at the same viscosity cotton had higher hot alkali solubility than wood pulp but correction for differences in alkali-resistant cellulose in the original materials brought the values very close to each other. A considerable decrease in $CO_2H$ number occurred at high D.P.

Kuriyama, S., and Mori, K., *J. Chem. Soc. Japan, Ind. Chem. Sect.* 56: 499–501 (1953); *cf. C.A.* 48: 11780; *C.A.* 48: 12405 (1954).

Red pinewood pulp was sulphonated and the amounts of lignin and sulphur were determined. Experiments were devised in which the degree of sulphonation of lignin in sulphite liquors at varying pH were used to examine the view of Erdtman (*C.A.* 43: 7682) that active radicals are present in lignin. It was stressed that Erdtman's "B-radical", which can be sulphonated at a pH below 7 and which hardly reacted with resorcinol, is not simple in nature; the reactivity of the radicals changes with slight variations in pH. The mechanism of sulphonation of lignin is discussed.

Odincovs, P. N., Gromovs, V., and Jakuseva, A. *Latvijas PSR Zinatnu Akad. Vestis* 1952, No. 11 (Whole No. 64), 31–41 (in Russian); *C.A.* 48: 14194 (1954).

The influence of the removal of polysaccharides from the wood substance on the solubility of lignin in sulphite liquor was investigated. Either partial or full removal of carbohydrates from the wood substance by hydrolysis with dilute sulphuric acid, solution with Cu-$NH_3$ solution, or decomposition by enzymes of *Coniophora cerebella* decreased very significantly the ability of lignin to dissolve in the sulphite liquor. The probable mechanism is that the sulphonation of the lignin-carbohydrate complex proceeds at the double bonds in the aliphatic chain of lignin, and the removal of the carbohydrates by the pretreatments converts lignin into a keto-form with elimination of the double bonds; this causes difficulties in sulphonation.

Ahlen, L., and Samuelson, O., *Svensk Papperstidn.* 56: 81–84 (1953); *C.A.* 48: 14195 (1954).

An investigation of two methods for the determination of methanol and ethanol in spent sulphite liquor and condensates from spent sulphite liquor.

Technical Association of the Pulp and Paper Industry, *Tappi* 37, No. 2: 127–129A (1954); *B.I.P.C.* 24: 542 (1954).

The method for the determination of water in pulp mill spent liquors (TAPPI Suggested Method T 641 sm-54) is based on a modification of the Karl Fischer titration for water and is applicable to spent liquors from calcium, magnesium, ammonia, kraft, and semichemical processes.

Brauns, F. E., Hlava, J. B., and Seiler, H., *Anal. Chem.* 26, No. 3: 607–608 (1954); *cf. B.I.P.C.* 24: 451; *B.I.P.C.* 24: 612 (1954).

A method is described for the determination of sulphur and barium in organic barium sulphonates. The barium in organic barium sulphonates, such as barium ligninsulphonates, is separated from the acid component by means of a small cation exchange column, and the sulphur in the eluate is determined according to Salvensen and Hogan (*cf. B.I.P.C.* 19: 153–154). The barium is then eluted with hydrochloric acid from the other end by turning the column 180° and determining the barium as barium sulphate in the usual way. One figure and one reference.

Richtzenhain, H., Abrahamsson, B., and Dryselius, E., *Svensk Papperstidn.* 57, No. 13: 473–477 (1954); *B.I.P.C.* 25: 58 (1954).

The solubility of sprucewood sulphonated under different conditions in cuprammonium solvent has been investigated. The cuprammonium solvent-insoluble residues always contain nearly equal amounts of lignin and carbohydrates. When sulphonated wood is hydrolyzed before the treatment with cuprammonium solvent, a more complete dissolution is obtained. A fraction of the dissolved lignin can be precipitated together with carbohydrates by acidifying cuprammonium solvent. When sulphonated wood is treated with cuprammonium solvent in the presence of air, it dissolves nearly completely. The resulting water-soluble ligninsulphonic acid can be isolated as quinine salt. It contains 1 sugar residue per 4 to 5 lignin units. Sugar residue can only be isolated by acid hydrolysis, but not by reprecipitation. The existence of chemical linkages between lignin and carbohydrates is discussed. Three tables and 24 references.

Gierer, J., Lindgren, B. O., and Mikawa, H., *Svensk Papperstidn.* 57, No. 17: 633–637 (1954); *B.I.P.C.* 25: 199 (1954).

Model investigations of lignin sulphonation have shown that lignin most probably contains benzyl alcohol and benzyl ether groups; these are formed in the oxidative polymerization of coniferyl alcohol, the probable course in the biosynthesis of lignin. In addition, the presence of *p*-hydroxybenzyl alcohol groups and also possibly of *p*-hydroxybenzyl ether groups has been demonstrated by specific color reactions. On the other hand, cinnamyl alcohol groups and phenylcoumaran structures, such as those present in dehydrodiconiferyl alcohol, do not seem to be as dominating in lignin as might be anticipated from the relative amount of dehydrodiconiferyl alcohol present in the mixture of dimers formed during the oxidation in vitro of coniferyl alcohol, although these two types of groups behave in some respects like lignin. Two possible explanations are offered. The one is that the cinnamyl alcohol groups and the phenylcoumaran structures present in the dimeric intermediates may be destroyed or changed in some way during the further oxidation to lignin. The alternative explanation involves the possibility that the principal path of lignin biosynthesis does not include essential amounts of the dehydrodiconiferyl alcohol structures as intermediates. Nine figures and 17 references.

Aulin-Erdtman, G., *Svensk Papperstidn.* 57, No. 20: 745–760 (1954), *cf. B.I.P.C.* 23: 725; *B.I.P.C.* 25: 284 (1954).

The ultraviolet absorption of 26 spruce lignin derivatives, including ligninsulphonic acids, lignothioglycolic acids, acetic acid lignin, and alcohol lignins, has been studied in various solvents and at varying pH values. The absorption curves are discussed and conclusions are drawn regarding the extrusion of sulphurous acid from ligninsulphonic acids in alkaline solutions, the absence of enolic groups, etc. The

"$\Delta\epsilon$-method" described in part IV of this series, has been used for studying the structural types as well as the amount of phenolic elements present in the lignin preparations. The presence of two types of phenolic elements in the lignin derivatives was indicated: (1) guaiacol elements which are not conjugated with extra-nuclear double bonds, and (2) phenolic components with extended chromophores, amounting to less than 3–4/100 methoxyl groups for materials prepared under mild conditions. Larger contents of the latter elements were found in some lignin derivatives which had been subjected to drastic conditions during preparation, such as high temperature or oxidation in alkaline medium. The values calculated for the content of the guaiacol elements varied somewhat with the type of preparation and the model phenol employed for comparison; the limits were 8 and 32/100 methoxyl groups. Only a slight increase, 3–4/100 methoxyl groups, was observed as a result of resulphonation of a low-sulphonated ligninsulphonic acid. Seven tables, seven figures, and 46 references.

Kratzl, K., and Schweers, W. I., *Monatsh. Chem.* 85, No. 5: 1046–1054 (1954); *B.I.P.C.* 25: 284 (1954).

The so-called "Hibbert building stones" could be separated chromatographically by applying the ethanolysis techniques to as little as 3 to 8 mg. of wood or isolated lignins. The methods are described in detail. The best developer was water - benzine (boiling at 100 to 110°C) - chloroform - methanol in the ratio of 5:7:2:1. The reagent used for spotting the chromatogram was the "Denis reagent" (no formula or reference is given, but presumably the Folin-Denis reagent for phenols, *cf. J. Biol. Chem.* 12: 239–243 (1912)). Besides sprucewood, the method when applied to Brauns' native lignin, periodate lignin, hydrochloric acid lignin, alkali lignin, ligninsulphonic acid, and a fiberboard showed the presence (in the ethanolysis mixture) of $\alpha$-ethoxypropiovanillone, vanilloylacetyl, 1 - (4 - hydroxy - 3 - methoxyphenyl) - 2 - propanone, and vanillin. There was strong indication that from sprucewood, $\alpha$-hydroxypropiovanillone was also isolated, and there were some spots that indicated the presence of unidentified ethanolysis products. None of the above products was found when coniferin or sodium propiovanillone-$\alpha$-sulphonate were subjected to the above techniques. Two tables, one figure, and 23 footnotes.

## ION EXCHANGE RESINS

Kin, Z., *Prace Inst. Celuloz. Papier.* 2, No. 2: 19–33 (1953); *cf. C.A.* 47: 8367; *C.A. 48:* 7297 (1954).

Two laboratory methods of producing cation exchangers from ligninsulphonic acids (LSA) contained in fermented spent sulphite liquor are: condensing LSA in the presence of a catalyst ($H_2SO_4$); or condensing LSA with aldehydes. The properties of various types of cation exchangers produced in this way were found satisfactory and their usefulness in softening water and demineralization of LSA was confirmed.

## MAGNESIUM-BASE PROCESS

Hazelquist, S. E., Ger. pat. 862,253, (Jan. 8, 1953); *C.A.* 48: 11058 (1954).

A process for the regeneration of magnesium bisulphite liquor. See U.S. pat. 2,572,929 (*C.A.* 46: 4232).

Rogers, C. E., *Pulp Paper Mag. Can.* 55, No. 2: 55–57 (1954); *B.I.P.C.* 24: 659 (1954).

The sulphite industry is a large consumer of oil and sulphur, the natural supplies of which are not inexhaustable. Of all sulphite processes investigated to date, the magnesium-base sulphite process offers the best possibilities for chemical recovery and avoidance of stream pollution. Five references.

## MISCELLANEOUS USES

Schwabe, K., Ger. pat. 763,557 (June 28, 1954); *C.A.* 48: 12366 (1954).

Thiocyanogenated ligninsulphonic acids useful as pesticides are prepared by slowly introducing a halogen into aqueous solutions of ligninsulphonic acids containing thiocyanates. Thus, a mixture of air saturated with 70 grams Br is passed through 150 ml. spent sulphite liquor (11 grams ligninsulphonic acid) containing 35 grams $NH_4SCN$ with stirring and cooling. The precipitation of the thiocyanogenated ligninsulphonic acid begins when about 35 grams Br has been introduced. The product containing a small amount of polythiocyanogen is sucked off, washed, and dried to give 12.5 grams product. The formation of polythiocyanogen by-products is prevented by adding 2 ml. of 25% aqueous $NH_3$ and 10 grams $AcONH_4$ to spent sulphite liquor before the treatment with bromine.

Tibenham, F. J., and Grace, N. S., *Ind. Eng. Chem.* 46, No. 4: 824–828 (1954); *B.I.P.C.* 24: 717 (1954).

The incorporation of alkali lignin into rubber compounds by coprecipitation from latex has previously been shown to yield vulcanizates with tensile strengths, hardness, and tear resistance comparable to those of black reinforced compounds. The properties of the vulcanizate depend, however, on the process of coprecipitation used. Treatment of the lignin with hexamethylenetetramine in the presence of the rubber yields a vulcanizate in which tensile properties and hardness comparable with those of a black-reinforced compound are combined with the resilience of a pure gum compound. Ligninsulphonic acid resulting from the acid cooking process has not shown the same promise as alkali lignin as a reinforcing filler in rubber. By an ion-exchange technique it may be modified to yield results similar to those given by alkali lignin. A material chemically related to lignin and potentially abundant is humic acid, obtained by the alkaline extraction of weathered outcrop coal. This material behaves in rubber much like alkali lignin, yielding products with the same general level of properties. Six tables and 17 references.

Frokjaer-Jensen, A., and Andreasen, A. H. M., U. S. pat. 2,670,298 (Feb. 23, 1954); *B.I.P.C.* 25: 340 (1954).

A material with a low density but a very high crush strength (suitable for insulating purposes, incorporation in concrete, etc.) is made by mixing waste sulphite or sulphate liquors (concentrated to 60% solids) with clay in a pugmill. From 1 to 2% of liquor on a dry clay basis is added and the mixture fired in a rotary kiln at a temperature of 1100 to 1125°C., after which it is sorted by grain size. The treatment results in a roughly 50% weight reduction of the untreated clay material.

## POLLUTION STUDIES

Southgate, B. A., *Water and Sanit. Engr.* 3: 88–91 (1952); *C.A.* 48: 2297 (1954).

A summary of the developments in the treatment of the following industrial wastes: gas liquors, metal wastes, food wastes, farm wastes, paper-pulp wastes, and tannery wastes. Twenty-four references.

Gellman, I., and Heukelekian, H., *Sewage Ind. Wastes* 25: 1196-1209 (1953); *cf. C.A.* 46: 2207; *C.A.* 48: 7230 (1954).

This investigation shows the relative importance of several factors which affect the rates of oxidation and purification (absorption) of soluble industrial wastes with activated sludge. The wastes studied were: rag, rope, jute, and sulphite cook liquors, boardmill white water, spent yeast nutrients, dairy waste, and chewing gum wash water. The results obtained led to the conclusions that: (1) the unimolecular reaction and $k$-value concept are well suited to characterizing the oxidation and purification of industrial wastes by activated sludge; (2) acclimatization is the major factor affecting these rates of oxidation and purification; and (3) B.O.D. loadings of at least 135 lb. per 1000 cu. ft. of aerator capacity per day are possible with resultant B.O.D. reductions of 90%, with

2000 p.p.m. sludge solids. Correspondingly higher B.O.D. loadings are possible at higher sludge concentrations.

Amberg, H. R., and Strang, A. G., *Tappi* 37: 307–313 (1954); *cf. C.A.* 47: 8366; *C.A.* 48: 11056 (1954).

The discharge of spent sulphite liquor into the Columbia River has caused an excessive filamentous growth of *Sphaerotilus*. An underwater diffusion line was therefore installed and through it the spent sulphite liquor is diluted to such an extent that the excessive slime growth is prevented.

Kleinert, T., and Wincor, W., *Das Papier* 8: 214–218 (1954); *C.A.* 48: 11786 (1954).

A critical résumé is given of the more common methods used for estimating stream pollution caused by spent liquors. A rapid method is advocated that involves (*a*) the determination of ligninsulphonic acid by the tyrosine technique (*C.A.* 47: 6655) and (*b*) the determination of the total oxygen required when all the organic matter in the liquor is subjected to wet combustion with $K_2Cr_2O_7$-$H_2SO_4$ under standardized conditions (*C.A.* 48: 357). The validity of these determinations was established by determining the O consumption (in terms of mg./100 mg. substance) in the case of spruce and beech ligninsulphonic acids, carefully purified by precipitation with quinoline; for pure sugars, hemicelluloses, and for a number of waste liquors. Organosolv lignins were also used in determining such oxygen consumption. In applying these techniques practically, it is essential to take adequate samples of the river water above and below the sulphite pulp mill, so as to avoid erroneous deductions. The use of Fairbairn's modified anthrone reagent for sugars (*C.A.* 47: 4239) was examined critically; despite its limitations this may serve a useful orienting purpose in rapidly estimating the sugars present.

Ganczarczyk, J., and Domanski, J., *Gaz, Woda i Tech. Sanit.* 27: 302–304 (1953); *C.A.* 48: 14202 (1954).

The object of the research were effluents of spent sulphite lyes discharged on a ground rich in iron. They caused a serious discoloration and increase of oxygen consumed on the water of the river into which they flowed. The purpose of the work was to obtain high enough purification of spent sulphite lyes to enable an effective self purification of the river. The composition of spent sulphite lyes was instable during the 1.5 years of the research: pH 6.8 to 7.3; O consumed 385.0–1087.1; Ca 89.0–179.0; Fe 24.0-162.0 mg. per l. Following coagulations were investigated: $Al_2(SO_4)_3.18H_2O$ 2500 mg. per l.-coloration 200 mg. Pt. per l., O consumed 73 mg. per l., pH 4.8; $Al_2(SO_4)_3.18H_2O$ 2500 + CaO 400 mg. per l.-coloration 60 mg. Pt., per l., O consumed 70 mg. per l., pH 7.0; $FeSO_4.7H_2O$ 1800 mg. per l. CaO 800 mg. per l-coloration 100 mg. Pt. per l., O consumed 44 mg. per l., pH 11.1; $FeSO_4.7H_2O$ + enough Cl to oxidize all the present Fe to trivalent + CaO 1000 mg. per l.-coloration 150 mg. Pt. per l., O consumed 75 mg. per l., pH 11.0; CaO 6000 mg. per l.-coloration 180 mg. Pt. per l., O consumed 40 mg. per l., pH 12.3; CaO 4500 mg. per l. followed by $CO_2$ saturation-coloration 100 mg. Pt per l., O consumed 38 mg. per l., pH 7.0; CaO 4500 + $CaOCl_2$ 100 mg. per l.-coloration 150 mg. Pt per l., O consumed 30 mg. per l., pH 12.2. The reported results are relative to the maximum impurity concentration. By doubling the flocculation time (30 instead of 15 min.) the absorption effect of the precipitate was increased and the discoloration was further diminished by 10 to 20% and oxygen consumed by 15%. The optimum coagulant dose could in this case be lowered by 15%. The precipitates obtained in coagulation contained large quantities of water (86.1 to 99.4%) and would dry up very slowly. The best purification of spent sulphite lyes (largest reduction of oxygen consumed) was obtained with calcium oxide followed by saturation with carbon dioxide or with calcium plus addition of $CaOCl_2$. The precipitate could be regenerated by calcination.

National Council For Stream Improvement, *Tappi* 37, No. 4: 106A, 110A, 112–116A (1954); *cf. B.I.P.C.* 23: 670; *B.I.P.C.* 24: 745 (1954).

Excerpts from the 1953 Annual Report of the National Council for Stream Improvement are given in which the activities and developments during the past year in sulphite, kraft, semichemical, white water, deinking, and strawboard effluents, stream analysis, aquatic biology, and dehydration of hydrogels are reviewed.

Orlob, G. T., and Eldridge, E. F., *Sewage Ind. Wastes 26*, No. 4; 520–530 (1954); *cf. B.I.P.C.* 21: 805; *B.I.P.C.* 24: 745 (1954).

As a result of the formation of a pollutional barrier, consisting of an oxygen-deficient mass of water confined within the channel of the Snohomish River at its entrance into Port Gardner Bay, impeding the normal migration of salmon, two large sulphite mills situated at the river mouth cooperated in the construction of an underwater disposal line capable of dispersing 22 million g.p.d. of concentrated digester liquor and wash waters through a series of outlets over a 1000-ft. section at a depth of 300 ft. in Port Gardner Bay. The pipeline is considered only a temporary solution, since both mills are seeking methods of eliminating or reducing waste by process conversions, such as changing from calcium to either an ammonia or magnesium-pulping base. Samples taken in 1949 and 1951 after the line was in operation were compared as to dissolved oxygen, spent sulphite liquor concentration and chloride content. In both cases, dissolved oxygen was never recorded at less than 5 p.p.m., spent sulphite liquor was recorded as high as 650 p.p.m. in 1949 and reached a maximum of 76 p.p.m. in 1951. As a temporary means, the method is considered to have a number of significant advantages over the old method of surface discharge. Six tables, four diagrams, four maps, and one reference.

Rabeler, G. E., *Tappi* 37, No. 6: 144–146A (1954); *B.I.P.C.* 24: 923 (1954).

The author describes the methods for conducting an industrial waste survey in a pulp and paper mill in three phases: (1) the acquisition of a thorough knowledge of all mill operations, (2) the measurement of all mill wastes (establishing water and materials balances and determining the effect of the wastes on the receiving waters), and (3) the preparation of a comprehensive report.

Hanson, J., *Yearbook Am. Pulp Paper Mill Supts. Assoc.* 34: 263 (1953); *Paper Mill News* 76, No. 25: 86, 88 (1953); *B.I.P.C.* 25; 144 (1954).

The author briefly summarizes the experience of one Wisconsin mill with ponding of spent sulphite liquor. The area within the loop of the Peshtigo River was selected with the aid of a recognized geologist who declared it safe. A pond 5 acres in area was constructed in this location; the operation is partly ponding and partly soil filtration and bacterial action. The waste liquor is hauled by truck to the pond; a trip is made every 30 min. The results so far look promising. Ponding is not a cheap way of waste disposal, but it does not require as large a capital expenditure as some other methods (yeast manufacture, evaporation and burning, etc.).

## PRECIPITATION OF ORGANIC AND INORGANIC COMPOUNDS

Hori, S., Jap. pat. 5352 ('53) (Oct. 19, 1953); *C.A.* 48: 11788 (1954).

Spent sulphite pulp cooking liquor is neutralized with ammonia and the ammonium sulphite thus produced is oxidized by bubbling through air to give ammonium sulphate.

Kleinert, T. N., *Monatsh. Chem.* 85, No. 5: 1174–1176 (1954); *cf. B.I.P.C.* 23: 672; *B.I.P.C.* 25: 318 (1954).

A preliminary report is presented on the precipitation of organic matter from spent sulphite liquor by cooking with slaked lime. Full details will be published in the *Pulp and Paper Magazine of Canada*. At temperatures above 150°C., the organic matter of spent liquors is precipitated very rapidly. For example, at 300°, 80% of the total was removed within 20 min. On the other hand, demethylation occurs much more completely at the higher temperatures. When precipitated at 350°, the organic matter contained only 0.5% methoxyl (on the ash-free basis), whereas that precipitated from the same liquor at 150° retained 15.2% methoxyl. One table and four references.

## REVIEW ARTICLES

Heron, W. M., *Paper Mill News 77*, No. 12: 70, 72, 74, 76 (1954); see *C.A.* 47: 12806; *C.A.* 48: 6695 (1954).

A review of progress in the utilization of spent sulphite liquor.

Sofue, O., *Chemistry and Chem. Ind.* (Japan) 7: 363–377 (1954); *C.A.* 48: 13218 (1954).

A review with 55 references.

Leopold, B., *Pulp Paper Mag. Can.* 55, No. 3: 184–186 (1954); *B.I.P.C.* 24: 625 (1954).

The author reviews recent Swedish research by Lindgren, Adler, and himself on the manner in which the lignin elements are linked together and on the nature and location of the sulphonatable groups in the lignin molecule. The results show that softwood lignin consists of guaiacyl propane elements connected to each other through ether and carbon-carbon linkages, probably randomly distributed in approximately equal proportions. All or most of the reactive groups are located at the $\alpha$-carbon atoms of the side chains and consist of hydroxyl or ether groups. Some of the groups consist of highly reactive hydroxyl or ether groups, some of them activated by phenolic hydroxyls; the remaining groups consist of ether linkages which are hydrolyzed or sulphonated only under acid conditions. The second type of linkages join the lignin to the rest of the cell wall, e.g., to other lignin or carbohydrate molecules. Eight figures and two references.

Marshall, H. B., and Neate, J. N., *Tappi* 37, No. 8: 174–190A (1954); *cf. B.I.P.C.* 24: 144; *B.I.P.C.* 25: 55 (1954).

Literature published during 1953 in the field is reviewed in an annotated bibliography, arranged under the subject headings: ammonia-base process, binding materials, chemicals, emulsifying and dispersing agents, evaporation and burning, fermentation, fertilizers, fundamental investigations, ion exchange resins, magnesium-base process, miscellaneous uses, pollution studies, precipitation of organic and inorganic compounds, re-use of sulphite spent liquor, review articles, sodium-base process, and tanning materials. 158 references.

Anon., *Chem. Eng.* 61, No. 9: 144, 146, 148 (1954); *B.I.P.C.* 25: 112 (1954).

Stream-pollution problems, a better understanding of lignin's chemical nature, and economical considerations of waste utilization are gradually changing the pulp industry's attitude toward this unavoidable by-product of pulping processes. Three roads to lignin utilization lie ahead: the use of whole lignin, its salts and ligninsulphonates; unit processing of lignin; and controlled systematic breakdown of whole lignin into lower molecular-weight organic materials. The first of these three possibilities has been investigated the most and promises the quickest return in the near future. Industrial uses of lignin include its application as a rubber reinforcement, asphalt-emulsion stabilizer, ceramic binder and deflocculant, dry leveler and dispersant, oil-mud additive, protein precipitator, and plastics extender. Ligninsulphonates have a number of uses: conversion to vanillin, road binders, adhesives, core binders, etc. Little work on commercial production of lignin derivatives by simple chemical reactions has so far been done; the systematic breakdown of lignin into its components is principally known from experimental lignin degradations. A wide field for future research is open. This article is based in part on a recent paper by Paul W. Wiley. Two illustrations.

Gilbert, E. E., and Jones, E. P., *Ind. Eng. Chem.* 46, No. 9: 1895–1912 (1954); *cf. B.I.P.C.* 24: 107; *B.I.P.C.* 25: 114 (1954).

This general review of the recent literature on the subject of sulphonation and sulphation includes a special section on lignin (p. 1904). Fifteen references to the lignin section.

Auchter, M. J., *Paper Ind.* 36, No. 8: 807–808 (1954); *B.I.P.C.* 25: 318 (1954).

A review is presented on the work of the Sulphite Pulp Manufacturers' Research League in the concentration and utilization of spent sulphite liquor. Among the numerous uses of the concentrated 50 to 55% solids liquor are its application as a dispersant in oil drilling muds, insecticides, cement, and carbon black and as a road binder. The production of torula yeast and lignin products (vanillin) is discussed.

## SODIUM-BASE PROCESS

Dzhaparidze, P. N., and Drakin, L. A., *Soobshcheniya Akad. Nauk Gruzin. S.S.R.* 11: 547–554 (1950) (in Russian); *C.A.* 48: 999 (1954).

Practical electrolysis of spent sulphite liquor is feasible as a source of sodium hydroxide suitable for the absorption of sulphur dioxide formed from decomposition of the anodic liquor. The resulting sodium sulphite can be recycled into production. Distillation of the anodic liquor yields organic acids and solid matter, which on thermal decomposition yields sulphur dioxide and carbon. A flow sheet is appended.

Bickell, L. K., and Trethewey, G. D., *Pulp Paper Mag. Can.* 54, No. 13: 110–116 (1953); *C.A.* 48: 3684 (1954).

By a cyclic process, sodium-base spent sulphite liquor can be used economically to effect chemical and heat recovery, increase yield, and eliminate stream pollution. By means of ion exchangers, e.g. Amberlite IRC-50, sodium is recovered from the smelt, obtained by concentration of sodium-base spent sulphite liquor, and simultaneously sulphide sulphur is recovered as hydrogen sulphide, which is burnt to give sulphur dioxide. The ion exchanger in the sodium form is stripped with sulphurous acid to give raw acid ready for cooking.

Gray, K. R., Crosby, H. L., and Steinberg, J. C., Can. pat. 499,736 (Feb. 2, 1954); *B.I.P.C.* 24: 687 (1954).

Waste cooking liquors from a soda-base sulphite process and an alkaline process are combined prior to evaporation and burning. The dissolved smelt after combustion is alternately carbonated (flue gas may be used for this purpose) under pressure and steam-stripped in a partial vacuum, the above reaction causing the formation of carbonate and bicarbonate followed by the removal of hydrogen sulphide. Recovered hydrogen sulphide may be oxidized to sulphur dioxide. Depending upon the final product desired, the carbonate solution resulting from the above treatment may be used in that form, converted to caustic soda by causticization, or treated with sulphur dioxide to produce sodium sulphite. One figure.

Gray, K. R., Crosby, H. L., and Steinberg, J. C., Can. pat. 499,737 (Feb. 2, 1954); *B.I.P.C.* 24: 687 (1954).

This is similar to Canadian pat. 499,736 (Feb. 2, 1954, cf. abstract above) except that a single carbonation at a pressure

from 20 to 165 p.s.i. and a temperature varying from 50 to 150°C. is followed by a single steam stripping of the hydrogen sulphide from the liquor under a vacuum of from 5 to 29 in. of mercury. One figure.

Gray, K. R., Crosby, H. L., and Steinberg, J. C., Can. pat. 499,738 (Feb. 2, 1954) (corresponds to U. S. pat. 2,675,297 (April 13, 1954)); *B.I.P.C.* 24: 687 (1954).

Carbonation of the sulphide-containing liquors (cf. Canadian pat. 499,736, abstract above) by successive stages involving carbonation under pressure and increased temperature followed by stripping of the hydrogen sulphide gas from the liquor by steam at reduced pressure is claimed. One figure.

Aries, R. S., and Pollak, A., Can. pat. 504,058 (July 6, 1954); *B.I.P.C.* 25: 77 (1954).

Sodium sulphide from spent liquors of the sulphate, sulphite, and neutral sulphite processes are mixed with sodium carbonate at temperatures of 275 to 295°F and in the presence of an excess of air to oxidize the sulphide to sulphite. This corresponds to U. S. pat. 2,640,758 (June 2, 1953); *cf. B.I.P.C.* 23: 858. One figure.

*Dr. F. Wochbl. Papierfabrik.* 82, No. 16: 655–656 (1954); *B.I.P.C.* 25: 144 (1954).

Rayonier's solution-phase process of converting sodium sulphide into sodium salts of carbonic acid (U. S. pat. 2,675,-297, granted to Gray and co-workers April 13, 1954; *cf. B.I.P.C.* 24: 862) is discussed. The corresponding German patent carries the number 897,647.

## TANNING MATERIALS

Sarten, P. M., Austrian pat. 176,628 (Nov. 10, 1953); *C.A.* 48: 1043 (1954).

Tanning extracts are obtained from wood and bark by extraction with water or spent sulphite liquor, with or without addition of sulphurous acid or its salts, and by direct or indirect steam heating. The comminuted material is soaked with water, etc., and the extraction is conducted at an excess pressure of 0.1 to 3 atm. The extract is washed from the wood, etc., in top-to-bottom flow and drawn off at the bottom of the extractor.

Nyman, G. A., Swed. pat. 141,636 (Aug. 18, 1953); *C.A.* 48: 1682 (1954).

Spent sulphite liquor or ligninsulphonic acids are chlorinated up to 50% Cl and treated at 100 to 200° with sufficient alkali to dehalogenate and desulphonate the product. The material obtained on acidification can be used as a dispersing agent, tanning agents, or raw material for making artificial resins.

Zak, H., Austrian pat. 177,205 (Jan. 11, 1954); *C.A.* 48: 2401 (1954).

A method is described for the production of tanning agents from spent sulphite liquor. Spent liquors from the processing of deciduous woods are mixed at elevated temperatures with concentrated wastes from viscose manufacture. The calcium sulphate formed is removed to such an extent that ≤1% CaO (dry basis) remains in the reaction mixture. The latter is then treated with cation exchangers to give free ligninsulphonic acids containing gallic acid derivatives and other compounds contained in natural tanning matter. This solution is then concentrated by evaporation to approximately 50% and heated to 150° for a short time. The resulting product is spray dried after addition of stabilizers, e.g. 1-naphthol sulphonic acid, to give a powder having good tanning properties.

Kyogoku, Y., Ochiai, F., and Hachihama, Y., *J. Chem. Soc. Japan, Ind. Chem. Sect.* 55; 813-814 (1952); *cf. C.A.* 47: 3016; *C.A.* 48: 7921 (1954).

A comparison has been made of the relative absorption of α and β-ligninsulphonic acids during tanning. In the first stage of tanning β-ligninsulphonic acid is preferentially absorbed, then α-ligninsulphonic acid becomes gradually the predominant reactant. The latter is composed of compounds with higher molecular weight and lower degree of sulphonation.

Stather, F., Herfeld, H., and Reich, G., *Ges. Abhandl. deut Lederinsts. Freiberg/Sa.* No. 10: 5–15 (1954); *C.A.* 48: 9733 (1954).

A study was made of the influence of the method of preparation of spent sulphite liquor on their tanning behavior and on the properties of synthetic replacement tannins made from them. Tests were made on eight sulphite cellulose liquors from three mills. These included four "soft", two medium, and two "extremely hard" cooks. Of these, three were fermented to remove sugars and five were not. All were freed from calcium and iron by heating with sodium carbonate. This purification lowered the organic nontannin but increased the ash content, so that the effect on tannin/total solids was negligible. No significant differences were found among any of the eight liquors with respect to tannin/total solids, tan value, combining value, salting out value (low in all cases) or character of leather produced (poor in all cases). Three series of syntans were made by condensing each of the eight lignosulphonate products with phenolsulphonic acid, phenolsulphonic acid plus 2-naphtholsulphonic acid, and dihydroxydiphenylsulphone, respectively (*C.A.* 46: 5874). No differences in tanning characteristics were found within any of these series. *Cf.* Buchanan *et al. C.A.* 41: 4941.

Kyogoku, Y., Dan, K., and Hachihama, Y., *J. Chem. Soc. Japan, Ind. Chem. Sect.* 56: 208–209 (1953); *cf. C.A.* 48: 7921; *C.A.* 48: 9734 (1954).

Ligninsulphonic acid, the main component of waste sulphite liquor, was fractionated into four fractions by salting out with calcium chloride at 60 to 90°. The rational analysis and tannin purity value (ALCA method) of each fraction were given. The ease of salting out increases with the degree of sulphonation; but the experimental tanning tests indicated that the tanning ability is inversely proportional to the degree of sulphonation, because the fraction with higher sulphonation degree hardens the surface structure of hide and inhibits further progress of tanning.

Baum, M., Camp, R. C., and Salvesen, J. R., *J. Am. Leather Chemists' Assoc.* 49: 281–285 (1954); *cf. C.A.* 40: 6860; *C.A.* 48: 12442 (1954).

The determination of the tannin value of ligninsulphonates is discussed. Tannery results show that ligninsulphonates have a higher tannin content than that shown by the A.L.C.A. standard hide powder shake method, which gives low results for ligninsulphonates because the conditions are not suitable for the absorption of ligninsulphonates by the hide powder. Tanning values for ligninsulphonates checking with tannery results are obtained by substituting 5 min. agitation in a Waring Blendor at 40 to 45° for the standard 10-min. shake at room temperature. Under these conditions 95% of ligninsulphonates is absorbed. When ligninsulphonates react with chromed hide powder, sulphate groups are displaced and weighed with the nontannin solids. The resulting error in tannin determination occurs in the analysis of all vegetable tannins but is most serious with ligninsulphonates and sulphited extracts. It can be corrected for by subtracting the difference between the sulphate contents of the analytical and the nontannin solutions from the nontannin solids, but a more convenient method of eliminating the error is desirable.

Marshall, H. B., Krizsan, M., and Henry, W. C., *J. Am. Leather Chemists' Assoc.* 49: 505–514 (1954); *cf.* Baum, *et al. C.A.* 48: 12442; *C.A.* 48: 13247 (1954).

Commercial fermented waste sulphite liquor was dialyzed against water for 10 days. The dialyzed material, after

passing through an ion-exchange column, represented ash- and sugar-free high-molecular ligninsulphonic acids. The dialyzate was similarly de-ashed, and sugars were removed by the method of Yorston (*C.A.* 44: 4247). The product represented low-molecular ligninsulphonic acids. A maximum of 72.3% of this applied low-molecular ligninsulphonic acid was rapidly absorbed by the hide powder, and this amount was not increased by variation in time or temperature. The unabsorbed portion of low-molecular ligninsulphonic acid was isolated after treatment with an excess of hide powder. It differed from high-molecular ligninsulphonic acids and low-molecular lignin-sulphonic acids in its low sulphur and methoxyl contents and in the presence of closely associated sugars. Hide powder absorbed high-molecular ligninsulphonic acids very slowly, but the rate of absorption increased rapidly with increasing temperature. Absorption of high-molecular ligninsulphonic acids was essentially complete after 10-min. shaking at 70°. Under these conditions hide powder absorbs approximately 46% of its weight of high-molecular ligninsulphonic acids or 23% of its weight of low-molecular ligninsulphonic acids. Both high-molecular ligninsulphonic acids and low-molecular ligninsulphonic acids are irreversibly absorbed. The results show that the ALCA standard hide powder method does not give the total amount of high-molecular ligninsulphonic acid available for reaction with hide.

Abramowicz, W., and Sarnecki, K., *Prace Inst. Celuloz-Papier* 3: 34–44 (1954); *C.A.* 48: 14203 (1954).

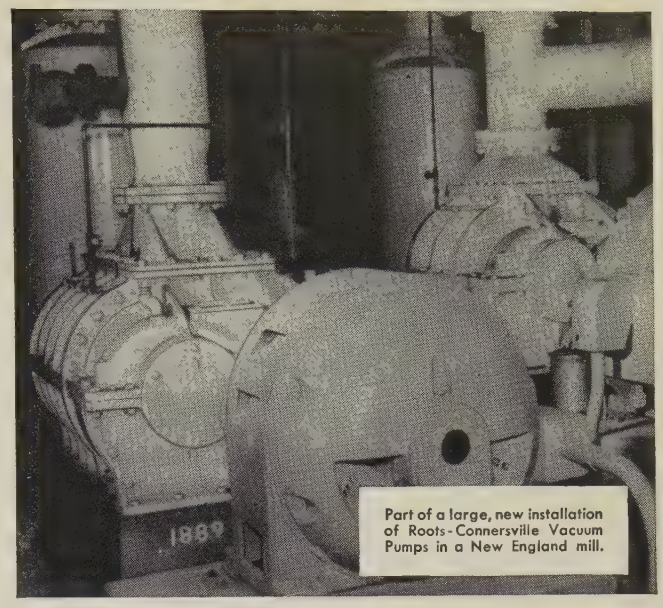
A method of isolating ligninsulphonic compounds from spent sulphite liquor and determining properties of their various fractions is described. The method consists of isolating individual fractions of ligninsulphonic compounds by combination of dialysis and salting out. The methoxyl and ligninsulphonic groups, the relationship between the degree of polymerization of ligninsulphonic acid and the amount of ligninsulphonic groups present and the tanning substance content are determined in each fraction. Results indicated that (1) by electrodialyzing waste sulphite liquor, two fractions of ligninsulphonic acid were separated, i.e. the dialyzed fraction containing 35%, and the nondialyzable fraction containing 65% of the spent sulphite liquor, respectively; (2) the highest content of tanning substance (83%) was obtained by salting out the nondialyzable fraction with common salts; (3) the lowest content of tanning substance (28.5%) was found in the dialyzed fraction; (4) the total amount of tanning substance in the whole waste sulphite liquor was 47%. Further experiments are indicated to determine the effect of the molecular size of various fractions on the properties of the tanning agents.

American Leather Chemists Association, *J. Am. Leather Chemists Assoc.* 49, No. 3: 174–207 (1954); *B.I.P.C.* 24: 613 (1954).

The provisional methods (February, 1954) of the American Leather Chemists Association cover methods for sampling and extraction of raw and waste materials, determination of nontannins and tannin, and analysis for sugar. A test for detecting ligninsulphonates (sulphite cellulose) in extracts of tanning materials is included. Two tables and four figures.

Russell, J. K., Craig, D., Byrd, G. J., and Maeder, R. L., Can. pat. 505,355 (Aug. 24, 1954); *B.I.P.C.* 25: 169 (1954).

Spent sulphite liquor to be concentrated for use as a tanning agent or adhesive composition is adjusted to a pH of 1.5 by addition of sulphur dioxide. The calcium salts are then precipitated by the addition of sodium, ammonium, or magnesium compounds and removed, and the pH is raised to 6.5–7.5. No scale is formed during concentration of liquor so treated and the concentrate shows improved heat stability and a light color.

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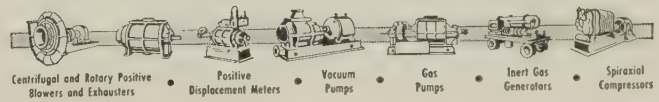
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# The Essential Requirements for a Successful Instrument Program in Paper Mills

EDWARD J. KEHOE

Mill operators everywhere are asking the same questions today. Where is instrumentation headed and how does it fit into the future? The visionaries are building automatic plants with it while an operator must forever take a practical view. We can't escape the fact that costs must always be weighed against results. That is probably why the paper industry has been a little slow to go all out for instrumentation as some others have. We have had instruments for years which showed good promise but for one reason or another just didn't work out. Some of the others did very well but we are quite sure they might have done even better. We are quick to blame the instrument manufacturer for our failures and are quite skeptical of new developments he makes.

Much credit must be given the instrument maker for the successful installations we do have, but is it right to lay all the blame upon him for the failures? Are we really doing our share in instrumentation?

It is a pretty well-established fact that we are going to need instruments to solve many of the problems which have plagued papermakers for years. Higher and higher speeds are demanding entirely new approaches. The "art" of papermaking is being displaced by the science of papermaking and instruments are taking an ever-increasing share of the burdens. Manual methods are out and automatic methods in production gains have been greater than anyone dreamed possible just a few years ago. Yet each year more and more companies are realizing that instruments alone are not the solution to our problems. We are becoming increasingly aware of the fact that with the instruments we must have people. People who know how to apply and maintain instruments to get results, and the results are in direct proportion to the effort these people expend.

Many people in the paper industry feel that we can still depend on the instrument manufacturer for the instruments and the skill and experience necessary in their design and application. Then all we need in our plants are good mechanics whom we can train to maintain this equipment. Their function is purely one of maintenance and therefore they should work under our regular maintenance departments. The engineering department can do the necessary planning for new installations and the mechanics can maintain them from then on. No additional supervision is needed and the over-all cost of the program is low.

There are many others who have come to believe that such an approach is very unrealistic. They believe that the instrument maker can't possibly understand all our problems as we do ourselves; that the plant project engineer isn't equipped to do a good job with control installations. They feel that instrument maintenance is highly specialized and that the knowledge and experience of the instrument mechanic can be profitably put to use in other ways besides just routine maintenance.

Before we decide which plan is right for our mill let's do a little thinking about it. If it is true that through the use of instruments we can cut costs and increase production, might it not be wise to direct more effort toward instrument development similar to what we are doing in paper chemistry and mechanical development? When we review the tremendous strides instrumentation has made in the past few years, isn't it quite within the realm of possibility that instrumentation might occupy a position on a par with the other phases of papermaking in another few years? With this in mind, what will be our requirements for manpower in the future?

Edward J. Kehoe, Steam Plant Superintendent, Marinette Paper Co., Marinette, Wis.

Isn't it quite true that very few people get their hands into as many of the plant processes as the instrument people? They reach out into almost every department in your plant. From boiler house and wood room on through finishing there is work for them to do. Already in some of our plants we have instruments employing every physical principle from simple mechanical to neucleonic. Looked at in this light, proper selection, application, and maintenance of instruments calls for some pretty high class talent. We should be seeking out and training the right kind of people now, for by the time we have them trained and they have sufficient experience we are going to have a big job for them to do. We must be sure we fit them into our plant organization so that they can do that job efficiently and thoroughly. Until recent years most instrument departments have operated as mere appendages to some other department in the mill. They have been shuffled around from one place to another without anyone giving much real thought to the problem of where they could function best.

Let us ask ourselves a few questions in this regard. Who, in our plant, can instrument people best serve: maintenance, engineering, technical, or production? Which of these people are most vitally interested in instrumentation? Who can best use the knowledge and experience gained by the instrument department to insure greatest future gains? The most successful instrument departments are those which perform a combination engineering-maintenance function and operate quite independently in association with the plant engineering department. The best of them are staffed with people who possess vision, practical know-how, honesty, and a genuine interest in instrumentation.

We have all suddenly become aware of the startling fact that each time we make a production gain in our plants our maintenance costs increase by an even larger percentage. This is quite understandable. We are making these gains, not through the addition of manpower, but through greater automation and mechanization. We're spending a great deal of time and effort to improve our machinery and reduce lost time, but we don't exert a proportionate effort toward improving our maintenance facilities. This becomes especially important with small groups such as instrument departments. Imagine an instrument mechanic in a two or three-man department who must obtain his work orders from a central dispatcher, his tools from a central tool crib, and his repair parts and supplies from a storehouse through a purchase requisition which he must first have signed by some department head. Yet instrument men in some mills work under conditions just that bad. A good part of their working day is spent in non-productive activities. Why shouldn't costs be high when we continue to drag such burdens? We must decide what work our instrument department is going to do and what can more economically be done outside the plant. Then we must make all the necessary equipment and supplies at hand and under the control of the instrument people. We must put them in a position to decide for themselves when each piece of equipment needs attention. Adequate records must be kept so that equipment can be replaced when it becomes uneconomical to keep it in proper repair. The records and experience of the instrument department should be consulted before new equipment is purchased so that standardization can be effected and needless expenditures for spare parts avoided.

The more cost minded we become the more important this matter of shop records becomes and the bigger headache it becomes for the instrument department. It certainly isn't economical for highly skilled instrument people to spend a large share of their time doing secretarial work. Very few departments, on the other hand, can afford a full time secretary. Someone has recently suggested that a secretary be employed who could be trained also to handle spare parts and do the small routine jobs in the instrument department. The suggestion is worth considering for it could greatly in-

crease the effectiveness of the department, both through better records and by releasing manpower for more critical work.

If we are going to keep costs down and efficiency up, we must organize and plan our maintenance activities. There are many fancy names for it, preventive maintenance; productive maintenance; and others; but they all boil down to the same thing—planned maintenance. We must total up the number and kind of equipment we service and provide sufficient manpower to care for it. After some experience is gained in this way we will be able to determine in advance what manpower requirements will be as we add new equipment in the plant.

Finally, if we are going to have good maintenance we must be adequately equipped to do good maintenance. Much of every instrument mechanic's time is spent in doing small jobs. Many of these jobs are most economically done by one man working alone. We can't afford to have this man going about from shop to shop to secure tools and wait for others to perform small services. The instrument shop must be completely equipped to handle the work we have decided they should do. The men must be trained to handle a great variety of small jobs themselves without running to others for help. Spare parts should be completely under the control of the instrument department and readily available without time-consuming red tape.

Stand back and take a broad view of the instrumentation in your plant. Scrutinize carefully each of its essential parts; instruments, people, and maintenance facilities. With tomorrow's needs in mind take steps now to correct any shortcomings you may find. Assure yourself of your share in the rich rewards instrumentation can bring you.

Presented at the Ninth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Philadelphia, Pa., Oct. 18–21, 1954.

# Cross Sectioning of Paper Products

R. P. STOLL

Cross sectioning of samples by various techniques yields valuable information on a great variety of paper products. Complete and accurate information on the number and relative thickness of layers and coatings, on the location and nature of contamination and defects, on the interfaces between coatings, and on the penetration of various coatings can be obtained.

Procedures and techniques which at first seem difficult, become rather simple with practice and experience. The information that an experienced microscopist can obtain from a well-prepared cross section can be of tremendous value in the solution of quality and manufacturing problems.

There are several very effective methods for the preparation of good cross sections. Four methods which have proved very satisfactory: (1) freehand sectioning, (2) sectioning nonembedded samples, (3) paraffin block sectioning, and (4) sectioning impregnated and specially treated samples will be discussed.

The simplest and most readily prepared type is the freehand section. The equipment required is rather simple. There are two types of freehand sections. The first consists of merely slicing through a sample with a freehand sectioner. A wedge is cut from the sample to be sectioned. This wedge is placed on a smooth, solid surface, such as a piece of masonite or heavy cardboard, and a sharp straight cut made with a freehand sectioner. The sectioner consists of a razor blade mounted in a holder. Holders of this type are available from Bausch and Lomb and the American Optical Co. Any thin razor blade, preferably double edge, is satisfactory. If a specific area or spot is to be sectioned, it is best done under a low power stereoscopic microscope, at approximately 10× magnification.

The sliced sample is trimmed to a convenient size and placed in a clamp with the cut edge up. The base of the clamp is the same size as the slide, 1 by 3 in., which permits it to be mounted on the mechanical stage of the microscope. This type section must be viewed by reflected light. Magnifications up to approximately 400× are practical. Higher magnifications require other lighting techniques, such as vertical illumination, because of the short working distance between the specimen and the objective. Stains and reagents are easily applied to the cut edge for such purposes as to delineate the interface between two layers. The interface between a pigment coating and a stock containing starch is accentuated by the application of iodine.

The principal advantages of this type section are: (1) they can be prepared quickly (3 to 4 min.), (2) they are a section of a sample in its entirety, and (3) the equipment is very simple.

A second type of freehand cross section produces a thin slice of the sample. The procedure is similar to that just mentioned, except that a second cut is made beside the first to obtain a thin section. A wedge approximately 2 cm. long and 5 mm. wide, at the narrow end, is cut from the sample. The wedge is held firmly on a solid surface and thin sections are sliced from the narrow edge in much the same manner bread is sliced. Observation of the cutting at 10× magnification, under a stereoscopic microscope, preferably a universal type, will facilitate more accurate cutting. With a little practice, sections approximately 30 to 40 mu thick can be cut. These sections can then be mounted in the conventional manner and examined by either reflected or transmitted illumination. This thin type section can also be prepared in a matter of a few minutes and is an excellent means for determining the number and location of layers in a sample and their relative thickness.

In many instances sections of the stock are not necessary, but rather thin, accurate sections of coatings or adhesive layers are important. For these cases, nonembedded sections have proved very satisfactory. They are referred to as nonembedded sections because the sample is not embedded in a paraffin block, plastics, or other material.

A wedge is cut from the sample, similar to that previously mentioned. With the aid of a lower power stereoscopic microscope the bulk of the fibers are shaved away from the back of the coatings with a surgical-type scalpel. Particular attention should be given to cutting away as much of the fiber as possible, without cutting into the coatings. This may appear somewhat difficult at first, but becomes a simple and fast operation with a little practice. The next step is to mount the stock-free section of the wedge on a suitable support. The support provides the rigidity necessary for sectioning. A heavy film of cellulose acetate has proved very satisfactory as a support. The material from the back of Dennison gummed labels works very well as an adhesive. After thoroughly drying, the sample is trimmed to a convenient size and placed in steel jaws, with the tip of the sample protruding beyond the jaws. These jaws were designed by Robert Titus, microscopist in the film division of Eastman Kodak Co. They have proved a tremendous asset to cross sectioning. The jaws containing the wedge are then placed in the microtome (Precision Rotary Microtome) and the cutting operation is started. Cutting is facilitated by viewing the sample as it passes the blade with a 30× stereoscopic microscope while it is being illuminated by a microscope spot light. The sections are usually cut at 3 to 5 mu in thickness. They are removed individually from the microtome blade with the aid of a dissecting needle. After a few preliminary cuts are made to obtain a clean, straight edge, one or two additional cuts are usually sufficient to produce a very satisfactory section. Using this nonembedded technique and the steel jaws, excellent sections of

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various coatings can be obtained in approximately 10 to 15 min.; this includes drying time for gluing the sample to the support.

A very useful technique developed by E. E. Jelly of the Research Laboratories of Eastman Kodak Co. has worked in very well with nonembedded sections. It is referred to as a sandwich-type cross section. When several slightly different samples are to be compared in a section, for example, as to the appearance of pigmented layers, it is possible to cut a sandwich cross section in which all the samples to be compared are sectioned in one operation. Usually as many as five or six can be viewed in a single cross section at magnifications as high as 400×.

The method of preparing sandwich cross sections is identical to that of nonembedded sections. The fibers are removed from each of the samples. They are then glued to each other, face to back, with the aggregate glued to a piece of cellulose acetate film. It is then trimmed, placed in the jaws, and sectioned.

Additional advantages of simultaneously cutting several sections in one sandwich are: (1) thickness variations are eliminated, (2) they can be photographed on one negative and analyzed using one print. This eliminates photographic and processing variations which would be encountered if several separate sections were photographed one at a time. This permits a valid comparison of the different cross sections.

The classical method of cross sectioning is the wax block section. Although they may at first appear somewhat more difficult to prepare, it can again be emphasized that with practice and experience, they are relatively simple. This type section requires about 30 to 40 min. to prepare but the method is very useful for the sectioning of samples that require a considerable amount of support when cutting.

Like the nonembedded technique, this method is used to obtain information on coatings and adhesive layers, or the thickness of various layers or coatings, rather than to obtain information on the paper stock itself. The preliminary steps in the preparation of the sample are identical to those of the nonembedded technique. When it has been glued to the support, it is cut into a wedge. The wedge is usually cut smaller than for the nonembedded section. The next step is to prepare two similar paraffin blocks, each approximately 10 by 15 by 25 mm. A heated spatula is applied to one of the blocks just long enough to melt the surface. The wedge is immediately embedded in the melted wax so the end of the sample is almost to the edge of the block. The surface of the second block is then heated and pressed against the first block. The sample is thereby embedded between the two fused blocks. The end of the block in which the sample is located is cut down, mounted in the microtome and sectioned. The sections are placed on a slide and thoroughly washed with xylene to remove the paraffin. When completely free of paraffin, they are rinsed two or three times with alcohol and mounted in an appropriate medium. The sections should be examined under the microscope before the applications of the xylene and alcohol to determine whether this treatment affects any of the coatings or layers. As previously stated, this method is very good for sectioning of pigment layers and other coatings where a considerable amount of support and rigidity is required.

Occasionally information is required on the stock of the sample in its entirety and a thin (3 to 5 mu) section is indicated. The cross section can be cut provided the stock is first impregnated with a material to hold it together. Without an impregnating agent the thin cross sections will disintegrate and yield no information about the stock.

The first step in the impregnation of a sample is to make an extract of the sample with an organic solvent. Benzene and ethylene chloride are two solvents that are applicable in most cases. It must be predetermined whether the solvent selected will have any adverse solvent action on layers which must be preserved in the cross section. It is advisable to test the solubility of the surfaces with the solvent and to examine the solvent used for the extraction for residues. Extraction of the sample with the proper solvents removes certain chemicals, such as sizing agents, which would inhibit the impregnation of the sample. Usually a 2-hr. extraction is sufficient.

There are many satisfactory impregnants, such as a solution of cellulose acetate in acetone or a 5% gelatin solution. If the acetate-acetone is used, a wedge of the sample is immersed in the solution. The acetone is allowed to evaporate, leaving the sample impregnated with and embedded in cellulose acetate. When thoroughly dry, the wedge is trimmed, placed in the steel jaws, and sectioned directly as in the case of nonembedded sections.

Another technique for impregnating sections, using cellulose acetate and acetone, has worked out very well. It consists of cutting a wedge of the sample approximately 50 by 5 mm. and hanging it as a wick in a 10% solution of cellulose acetate in acetone. It should be hung so that about one third of the sample is immersed in the solution and allowed to stand for about 24 hr. The evaporation of the acetone will drop the level of the solution below the bottom of the sample. The sample is then trimmed to a convenient wedge, placed in the steel jaws without additional support, and sectioned. This technique works very well for both uncoated papers and coated stocks.

If a gelatin is used the sample is immersed in a 5% solution for approximately 6 hr. to impregnate the sample. Then successive immersions of the sample for a few minutes at a time, with drying periods between, will encase the sample in gelatin. After thorough drying it is cut into a wedge and sectioned.

Though these impregnating techniques are somewhat lengthy, it is often the only practical method of cutting sections that will yield the information desired.

Of almost equal importance to the cutting of good cross sections is the mounting of the sections on a slide and the pressing of the sections. The mounting medium selected should have a refractive index, viscosity, and other characteristics that will permit an accurate observation and analysis of the section. It is usually necessary to press the sections on the slide so that their entire length can be examined with only slight adjustments of the focus. After the section has been mounted and covered with a cover glass, it is pressed for approximately 15 sec.

If stains or reagents are to be applied to cross sections, they are usually left unmounted or suspended in water or some other medium that will permit the stains or reagents to react with the section. For freehand sections mounted in a clamp, it is a simple matter to apply solutions to the cut edge by means of a glass rod.

There is a considerable amount of information that can be obtained from the use of stains and reagents, such as the identification of certain materials, the solubility of various layers and coatings, and the delineation of interfaces. Certain dyes can be used to identify and differentiate clear layers from one another; such as gelatin and acetate layers.

Micrometry is an important phase of microscopy associated with cross sectioning. The microscopist is frequently called upon to furnish information as to the thickness of various coatings and layers. This can be done readily provided the proper equipment is available. A micrometer occular marked with a graduated scale can be calibrated using a micrometer object slip. This gives a specific value for each occular division at the particular magnification used during the calibration. The object slip is then replaced by the slide containing the cross section to be measured. Another procedure is to take a photomicrograph of the section and measure the thickness of the layers in a print. Of course, the total magnification of the photomicrograph must be determined so the

proper conversion can be made. For example, a layer measuring 25 mm. in a photomicrograph taken at 500× magnification, is actually 50 mu thick.

All cross sections are made much more valuable if photomicrographs are taken and passed on to those interested. Sections seen under the microscope may be quickly photographed for record. A finished print can be obtained in less than 3 min., by the use of a Land camera with the proper microscope adapter.

If several prints are needed or if photomicrographs of higher quality or if color prints are needed, more elaborate photographing equipment, along with a dark room, and processing facilities are required. There is a large variety of photomicrographic equipment available which use a variety of film sizes. For example, there are photomicrographic cameras that use sheet film, others use the popular sizes of roll film (color as well as black and white) and others use glass plates.

The usual magnifications at which cross sections are photographed are from 100× to 500×, although higher magnifications are not uncommon. Either contact prints or enlargements can be made from the negatives.

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# Determination of the Degree of Pollution of Waters Containing Spent Sulphite Liquors

THEODOR N. KLEINERT and WILHELM WINCOR

The introduction of spent sulphite liquors and residual liquors from the production of alcohol (*1*) into flow waters can give rise to a considerable degree of pollution of the water due to fungus growth, impoverishment of oxygen, discoloration, foam formation (*2*), and odors, but in certain cases this may not necessarily be injurious. Determinative factors are the dilution ratio, the manner in which the spent liquors are distributed in the flow, and the degree of aeration of the flowing water brought about by natural, or artificially produced, flow conditions. On the basis of practical experiments carried out in America (*3*) a spent sulphite liquor concentration of less than 1:20,000 (50 p.p.m.) can generally be tolerated in flow waters, both from consideration of fungous growth and of fish protection. It is essential that there should be a uniform distribution of spent liquor in the flow and the dumping of liquor in batches should be avoided.

Liebmann (*4*) has studied the special case of a spent sulphite liquor drained into the Danube (at Kehlheim) in more detail and found that under the prevailing conditions the water containing the spent sulphite liquor was detectable as a stream of waste water, essentially unmixed, flowing close to the bank to a distance of more than 30 km. The same author has also shown that, since the spent sulphite liquor is heavier than water, it tends to flow in layers in such a way that the deeper layers are polluted to a higher degree than those on the surface: this is also shown by the fungous growth. For the self-purification of streams loaded with spent sulphite liquor, it is therefore of importance that there should be uniform distribution. A uniform liquor distribution is also necessary for sampling in carrying out investigations on the water for degree of pollution, especially for analytical and analytical-biological tests. As a rule sampling must be done at a river point where thorough mixing has already occurred. In other cases, samples must be taken at a number of different points at the same flow cross-section and the results evaluated by considering the rate of streaming. It has proved convenient to take mixed water samples at short time intervals, e.g. by using mechanical sampling devices.

Since the decomposition of organic substances in river courses is brought about chiefly by biological oxidative processes, it is necessary to determine the oxygen consumption required for such a decomposition. The biological requirement (*5*) gives important information in evaluating waters which are contaminated by organic materials, such as, for example, spent sulphite liquors. A suitable technique for the determination (*6*) and a proper interpretation of the findings are of practical importance. Generally, as in the case of household and city waste waters, the biological oxygen consumption over 5-day period ($B.O.D._5$) is determined, although this period of time appears arbitrary in the case of waters containing spent sulphite liquors. Also the amount of oxygen dissolved in the river water is important. Flowing water always receives varying amounts of atmospheric oxygen, so that conditions in practice are, in most cases, more favorable than the conditions of the test for determining biological oxygen demand. In determining the dissolved oxygen (*8*) special attention must be paid to the presence of reducing materials (*7*) in spent sulphite liquor contaminated waters. The biological decomposition of the sugars and carbohydrates of waste liquors takes place quickly. Thus in the 5-day experiment 70% and more of the spent liquor sugars and carbohydrates (*9*) are consumed. Also the lignin substances (*10*) are decomposed biologically, though much more slowly. While biological oxygen demand gives a good indication for evaluating waters containing spent sulphite liquors, one must bear in mind that the results may be influenced by many factors, such as the content of nitrogen and phosphorous compounds which are indispensable for the life of microorganisms, and also the absence of materials which inhibit the vital processes. The length of time necessary for the experiment prevents its use extensively for river supervision. A method by other means, preferably chemical, is therefore desirable.

In the following, attempts will be made to establish, as accurately as possible, the state of pollution of river waters containing spent sulphite liquor by means of a simple, quick method of investigation. This is achieved by the determination of the total oxygen demand of the organic substances concerned, and completed by the determination of the lignin sulphonic acids and by the total sugars.

As has been briefly referred to by E. Schmidt (*11*) the determination of permanganate number generally used in the analysis of waste water is unsuitable for the evaluation of waters containing spent sulphite liquors. It gives criteria neither for the biological demand nor for the total oxygen requirements necessary for total oxidation. Stundl (*12*) has also briefly referred to the differences between permanganate consumption and the value of the $B.O.D._5$. The total oxygen demand is of special importance since it stands in direct relation to the total organic matter in the waters, and therefore constitutes a direct measure of pollution.

For the determination of lignin substances in waters containing spent sulphite liquors or in spent sulphite liquor itself, new methods such as bromometric (*13*), colorimetric (*13*), optical absorption (*14*), or analytical precipitation (*15*) have been published recently.

For the estimation of the oxygen necessary for total oxidation of organic materials, the dichromate-sulphuric acid method given by Zimmerman is in use for various practical purposes, and different procedures (*16*) for a number of organic waste materials (*17*) have been tested. For comparison, experiments using a silver sulphate catalyst as proposed by Muers (*18*) were also made. Our own investigations (*19*) have shown that oxidation of cellulose, hemicellulose, and glucose by means of dichromate without the addition of a catalyst is almost complete, and with this method approximately theoretical values have been obtained. It is essential

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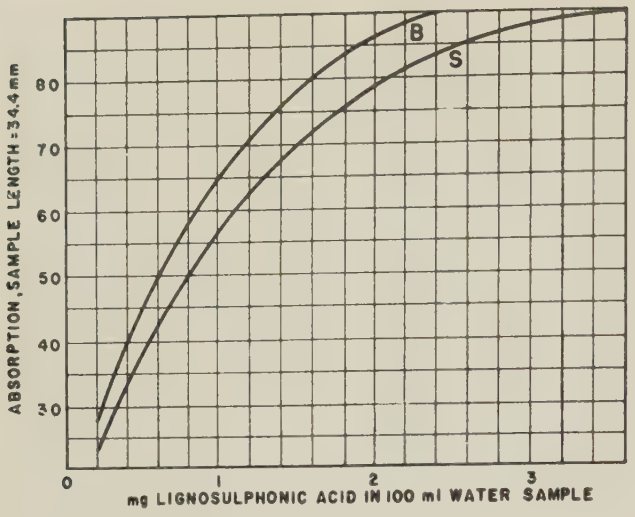


*Fig. 1*

that the ash-free dry weight of the initial material be accurately determined. In some experiments, the value of the dry material was determined by the method of Karl Fischer.

Spent sulphite liquor contains, besides carbohydrates, dissolved lignosulphonic acid salts. When using the dichromate-sulphuric acid method for determining total oxygen consumption of water containing spent sulphite liquor, it is therefore important to check whether, in the cases of lignin or spent liquor material, the dichromate-sulphuric acid method gives a complete oxidation value, and thus reproducible results. Various experiments were therefore carried out on different lignin preparations and the dried substance of spent sulphite liquors, using the dichromate-sulphuric acid method with and without the addition of silver sulphate, and, for comparison, the precise potassium iodate-sulphuric acid method given by Strebinger (*20*) was also used. These methods, even in the case of lignin materials, gave approximately concordant values.

The suitability of acid dichromate total oxidation thus was established, and it proved to be a rapid reproducible method for the examination of water containing spent sulphite liquor. To establish the fraction of lignin material in the total oxidation values, the lignin sulphonic acids from spruce and beech spent sulphite liquor were precipitated with chinolin or 8-oxychinolin, and the purified acids totally oxidized with dichromate sulphuric acid. In the same manner tests were carried out on the total oxidation of hexoses and pentoses present in spent sulphite liquor. The oxygen demand required for the total combustion of the substances investigated was determined by the following method.

About 50 mg. (calculated ash-free) of the substance to be investigated was weighed out in a 1-ml. glass beaker and placed with this in a 250-ml. flask with ground-glass stopper containing 50 ml. of distilled water. By tipping the flask, the substance was dissolved in the water. Then 14 ml. 1 *N* potassium dichromate solution (conveniently done by weight with a weighing pipet or by means of a microburet) and finally 80 ml. of concentrated sulphuric acid were added to the contents of the flask, so that the final concentration of sulphuric acid in the flask was about 55% by volume. The contents of the flask were refluxed for 10 min. after the addition of a boiling bead. The liquid in the cooling tube may be rinsed out with a little distilled water into the flask and the condenser removed. The contents of the flask were then transferred to a 1-liter Erlenmeyer flask and diluted with distilled water to about 500 ml. An excess of approximately 10% KI solution was added and the flask allowed to stand closed for about 5 min. The mixture was then diluted further with distilled water to 750 to 800 ml. and the excess iodine back-titrated with 0.1 *N* thiosulphate solution in the presence of starch.

The waste water samples were investigated in a similar way. Table I shows the oxygen consumption values of pure, ash and sugar-free lignin sulphonic acid from spruce and beech spent sulphite liquors, of hemicellulose, and of typical hexoses and pentoses, expressed as milligrams oxygen, based on 100 mg. oven-dry substance.

**Table I. Oxygen Demand, Milligrams Oxygen per 100 Mg. Moisture-free, Ash-free Organic Material**

| *Substance* | *On total oxidation by means of dichromate-sulphuric acid without the addition of silver sulphate as catalyst* |
|---|---|
| Lignosulphonic acid ash and sugar-free (beech) | 160.0 |
| Lignosulphonic acid ash and sugar-free (beech) | 161.9 |
| Lignosulphonic acid ash and sugar-free (spruce) | 160.8 |
| Lignosulphonic acid ash and sugar-free (spruce) | 161.0 |
| Lignosulphonic acid ash and sugar-free (spruce) | 160.0 |
| Dry solids, spruce spent sulphite liquor | 132.1 |
| Dry solids, spruce spent sulphite liquor | 130.1 |
| Dry solids, beech spent sulphite liquor | 132.5 |
| Hexose (glucose) | 106.6 |
| Pentose (arabinose) | 106.6 |
| Hemicellulose | 118.4 |

For comparison Table II shows the oxygen consumption values for organosolv lignins which are produced according to the method of Kleinert and Tayenthal (*21*).

**Table II. Oxygen Demand, Milligrams Oxygen per 100 Mg. Moisture-free Ash-free Organic Substance**

| *Substance, organosolv-lignin* | *On total oxidation by means of dichromate-sulphuric acid without the addition of silver sulphate as catalyst* |
|---|---|
| Beech | 170.3 |
| Spruce | 177.8 |
| Pine | 181.0 |

For determining the fraction of lignin sulphonic acid, the previously used tyrosine method (*13*), was employed, with the difference that the absorption values were based directly on the ash and sugar-free lignosulphonic acid, precipitated several times with chinolin. Figure 1 shows the relation between concentration and absorption for precipitated beech and spruce lignosulphonic acids using a Lange photocolorimeter with liquid layers of a thickness *d* of 34.4 mm.

As in the previous work (*13*), the absorption coefficients $\beta$ for the layer thickness 1-mm. were calculated from the general absorption equation

$$\beta = \frac{2 - \ln (100 - p)}{d}$$

where $p$ represents the absorbed light as a per cent. The relation between concentration and $\beta$-values is shown in Fig. 2.

The dichromate total oxidation values of waters containing only spent sulphite liquors give very important criteria with regard to the loading by organic substances. In practice, to evaluate the introduction of pulp mill waste water into a stream, it is recommended that the dichromate combustion values of the flow waters above and below the mill be compared. Of course, it is assumed that a sufficiently large number of samples are taken so that the results may be considered to be average. From the difference of the total oxidation values taken above and below the mill good information can be provided on the loading brought about by the mill concerned.

From the dichromate total oxidation values and the absorption values of the tyrosine reaction, conclusions can be drawn on the amount of carbohydrate substances present. In addition, it appears advisable to determine the total amount of carbohydrates by direct methods.

For determining the total reducing sugars in spent sulphite liquors, the reduction of Fehling's solution and determination of the copper oxide is used (*22, 23*), while for determining the amount of fermentable sugars, the isolation and determination of the carbon dioxide on fermentation is used (*24*). These control methods are rather troublesome and require a lot of time for carrying out. Also, some deviations are shown from the actual carbohydrate values, since not all carbohydrates have reducing power or are fermentable.

For this reason it seemed desirable to evolve a rapid method for the determination of total carbohydrates, which would include both different kinds of sugars as well as the lower molecular celluloses, which generally occur in pulp mill waste waters. Such a method of determination would have practical value even though the attainable results were approximate values. Recently, various authors have investigated in detail methods for carbohydrate determination using anthrone reagent (*25*). Fairbairn's (*26*) modified anthrone reagent has proved suitable with regard to the stability of the reagent and the reproducibility of the coloration.

We have carried out model experiments using Fairbairn's reagent with various pure sugars such as generally occur in spent sulphite liquors, and tested the effect of such factors as reaction time, reaction temperature, concentration, etc. (*27*). They show that the individual sugars have characteristic absorption-concentration curves. These curves exhibit a low interdependency between concentration and adsorption.

From these results it follows that the carbohydrate determination by means of anthrone reagent gives only preliminary values in the case of spent sulphite liquor sugars; this is because the quantity ratio of the sugars contained in the spent sulphite liquor or alcohol residual liquors is very different. However, the color of the anthrone reaction gives an estimation of total carbohydrate content of water containing spent sulphite liquors and the colorimetry of such waters with anthrone reagent completes for practical purposes the investigation of waters containing spent sulphite liquor.

## SUMMARY

The simplest way of estimating the degree of pollution of waters containing spent sulphite liquors is to determine the total oxygen demand on total oxidation of all the organic materials by means of dichromate-sulphuric acid, and to determine the lignin sulphonic acid by means of tyrosine reagent. In model experiments the oxidation values of ash and sugar-free lignin sulphonic acid precipitated with chinolin from beech and spruce spent sulphite liquors were determined; further, the dry solids of some beech and spruce spent sulphite liquors, and finally of some typical carbohydrates were determined by means of dichromate sulphuric acid. It could further be shown that, by using the modified anthrone reagent of Fairbairn, a rapid preliminary evaluation of total carbohydrate fraction in water containing spent sulphite liquors is possible.

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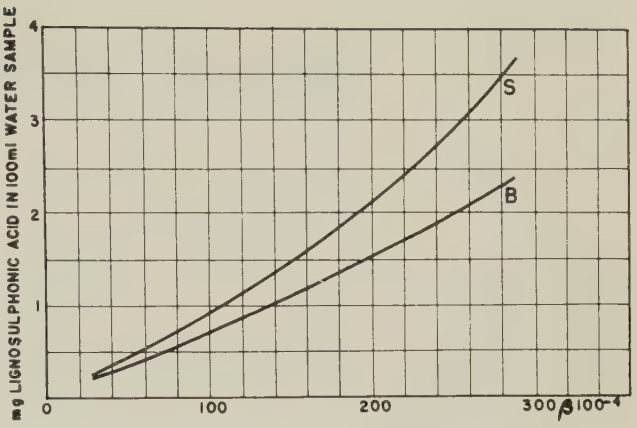


*Fig. 2*

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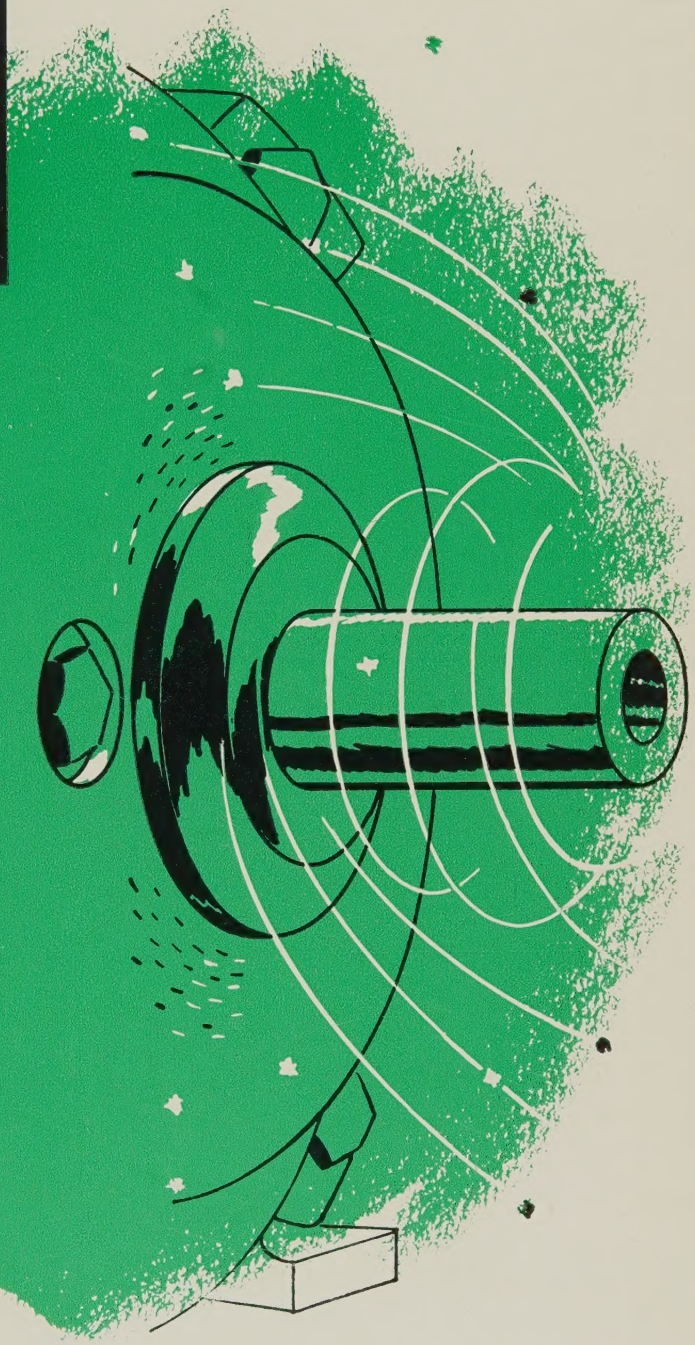
Tenth Engineering Conference, Rice Hotel, Houston, Texas, November 7–9, 1955.

Tenth Plastics-Paper Conference, Brooklyn Law School, Brooklyn, N. Y., November 14–15, 1955.

Forty-First Annual Meeting, Commodore Hotel, New York, N. Y., February 20–23, 1956.

Seventh Coating Conference, Benjamin Franklin Hotel, Philadelphia, Pa., May 7–9, 1956.

# IF...



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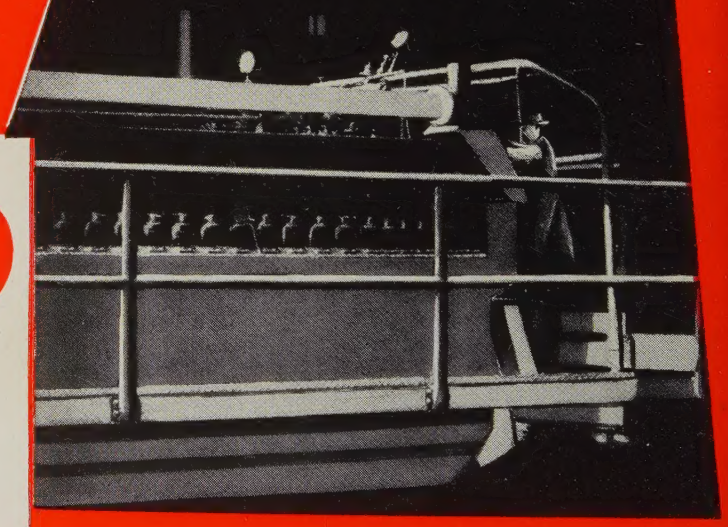

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